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* Indicates Illustrated Articles.

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THE ILLUMINATING ENGINEER

Vol. 1 MARCH, 1906 No. 1

A Year's Progress in Illumination

BY E. L. ELLIOTT

The year 1905 has witnessed a greater general progress in the science and art of illumination than has taken place in any single year for more than a decade. While no revolutionary new discoveries have been made, there have been marked developments and adaptations of previously discovered principles, resulting in the commercial advent of improved forms of light-sources, which are likely to have a far-reaching effect in future illuminating practice.

In the field of light production from electricity, both the incandescent and arc lamp have appeared in new forms, which are distinctly above the level on which lamps of this type have been running for a number of years, and which for a time seemed to be the practical limit of their progress. In both cases the improvement is the result of a "return to first principles," so to speak. Thus, the tantalum and osmium lamps, which represent the highest efficiency in incandescent electric lighting at the present time, owe their superiority simply to the use of metallic wires for the incandescent body in place of carbon. Those familiar with the history of the incandescent lamp will recall that Edison spent two years working with various metallic wires in his first attempts to produce an incandescent lamp, before abandoning them for the filament of pure carbon. Metallic tantalum in a state in which it could be drawn into wire was not at that time known to the scientific world.

The tantalum lamp in its present form is a commercial possibility by reason of the discovery of a practical method of producing malleable tantalum.

The discovery of the fact that tantalum is malleable in a pure state, and of the means of securing this condition of purity are due to Dr. Bolton, the chemist of the well-known electrical works of Siemens & Halske, of Berlin, Germany. The metal is sci-

entifically classed among the "rare," or "infusible metals," for reasons which are self-evident. The process of purifying the metal depends upon the use of the electric furnace; and thus the knowledge and development of one use of electricity makes possible improvements in its use in other fields. In constructing the tantalum lamp the wire is wound back and forth between two small reels with insulated arms, and enclosed in a glass bulb from which the air is exhausted. The lamp has two advantages over the carbon filament lamp; namely, a higher efficiency, and a light more nearly white in color. At present the price of pure tantalum is so high as to make the lamps comparatively expensive. The German lamp sells for one dollar in Europe. Tests made on these lamps both in this country and abroad show that an efficiency of 2 watts per candle the lamp will give an average life of at least 700 hours. Considering the cost of current at 5c. per k. w. hour, and the lamp at $1.00, the saving in cost of current would represent a profit of over 150 per cent. on the investment.

The use of rare metals as filament material brings forth as a question of vital importance the possible supply of these metals.

The fact may seem rather curious at the first thought that the supply of any given metal is largely determined by the demand, and this is true even in the case of rare metals which are found only in exceedingly small quantities and in few localities. Thus, when the Welsbach gas mantle was put on the market, thorium oxide, which is the chief constituent of such mantles, was worth twenty dollars an ounce; it is now worth less than half of that per pound. The enormous increase in the use of platinum necessitated by the incandescent lamp has increased the supply to such an extent as to keep the price at nearly a level. It is not unlikely that the commercial demand for tantalum will lead to the discovery of new sources and increase the production to such an extent as to materially reduce the present price, and thus in time cheapen the cost of incandescent lamps using it as a filament.

The tantalum lamp has become a commercial success in Germany, where the demand is said to exceed the supply, notwithstanding the high price. American manufacturers are experimenting with its production, and the coming year will no doubt witness its commercial *debut* in this country.

Another well-known and wealthy German company has been experimenting with a lamp of the same general principle, but using metallic osmium in place of tantalum. While they do not as yet seem to have met with the success that has attended the introduction of the tantalum lamp, it is nevertheless of such theoretical possibility that its commercial advent may be proclaimed at any time.

Since the additional cost of the metal filament lamp is practically all due to the intrinsic value of the metal itself, the introduction of such lamps will of necessity put the matter of "renewing" or "refilling" lamps on an entirely different basis from what it has occupied since the old days when from 40 to 80 cents worth of platinum was used in the construction of an incandescent lamp. It is obvious that a burned out lamp containing 50 to 75 cents worth of metal can no longer be relegated to the scrap heap. It

would seem logical that such a condition must result in central stations generally adopting the plan of free renewals, by which they will come into possession of burned-out lamps, and of some system of uniform rebates by the manufacturers for the return of burned-out lamps by individual users.

After more than a decade of running on a practically dead level as to quality and efficiency, the carbon filament lamp has taken a new lease of life by reason of the developments made during the past year in the laboratories of the General Electric Company. In this case also the improvement is rather to be characterized as a development than an actual new discovery; and, as in the case of the tantalum lamp, the improvement is made possible by the action of that most remarkable of electrical agencies, the electric furnace. Briefly described, the improvement consists in subjecting a treated filament, that is, a pure carbon filament which has received a deposit of graphitic carbon on its surface, to as high a temperature in the electric furnace as it will withstand without rupture. The action apparently is a semi-fusion of the graphitic carbon, which produces a distinct change in its physical characteristics, converting it from a more or less soft and friable substance into one having almost the qualities of a malleable metal, and also changing its electrical conductivity in an equally marked degree. In its ordinary state black carbon and graphite has its electrical resistance lowered by raising its temperature, acting exactly the reverse of the metals in this respect, while the carbons after treatment in the electric furnace show a higher electrical resistance when heated to incandescence, and thus resemble the action of a metal. For these reasons the filaments are called by the manufacturers "metalized filaments,"—a name not altogether felicitous, as it suggests to the layman that metal enters into their composition or structure in some manner, which is not the case; they are practically pure carbon as before, the change produced in this special treatment being wholly physical.

The increase in efficiency of such filaments, that is, their ability to withstand a higher temperature without disintegration than the old forms of filament, is marked amounting to at least 20 per cent. gain over the old form of 3.1 watt lamp, which has been considered the practical limit of efficiency heretofore.

The manufacturers thus far are only putting out lamps with these filaments in the higher candle powers, from 40 to 100, and at an efficiency of 2½ watts per candle, rated on mean horizontal intensity. Tests of these lamps show that their useful life at this efficiency may be safely counted as 500 hours, in many cases exceeding this by 20 per cent. The filaments also have the further desirable property of blackening the bulbs by use much less than the common form of filament, so that there is a scarcely perceptible difference in the color of light produced from the beginning to the end of their life. The cost of production of such lamps, while necessarily slightly greater than the older forms, is not sufficient to enter into the commercial side of the question to any considerable extent; in fact, at the present market prices the cost of renewals will not exceed that of the 3.1 watt type of the ordinary incandescent lamp.

In arc lighting, the use of the flaming arc has finally become established as an undoubted practical success. The general theory upon which the greater economy secured by this type of lamp depends rests upon old and well-known facts. First, the light-source is incandescent vapor; and incandescence from a substance in the gaseous form is always secured at a higher efficiency than when produced from either solids or liquids. Second, the material which is vaporized is itself a better radiator of light than amorphous, or black carbon. These facts have been known to scientists for years, and were worked upon by electricians in the early days of the industry. It is all the more remarkable, therefore, that, after having been abandoned by the profession, the work was taken up by a novice in this particular branch, and carried to a successful conclusion. Prof. Blondel, of Paris, one of the foremost authorities in the world on the subject of arc lamps, thus gracefully acknowledges the merits of Bremer's work.

"By a happy circumstance the latter (Bremer), who was not an electrician, and unlike many contemporaneous specialists, ignored the studies made and the results obtained previously upon carbons of that nature, was not discouraged or halted by the inexact scientific prejudice as to the necessity of high temperatures. Moreover, his researches, often ill-directed, were followed with remarkable perseverance and crowned with a legitimate success, notably, at the Exposition of Paris in 1900. This reopened a subject which had appeared to be closed, brought to light forgotten work, and excited anew on the part of numerous seekers, including the author of this communication, a desire to increase the means of combating the alarming progress of gas lighting."

In the mechanical construction of the lamps there is also a notable return in one respect to the earliest form of arc, known as the Jablachkoff candle; that is, in placing the two carbons side by side, and at a slight inclination to each other, the arc being held in position by the use of an electro magnet placed above.

Several successful makes of flaming arc lamps are now being imported from Germany and England and offered for sale in this country; and the demand seems to exceed the supply. Lamps of this type are made to run on either direct or alternating current circuits; the direct current running at about 40 volts at the arc, and two in series of 110 volt circuits, or in any higher number on higher voltages, and ranging in candle powers from 1600 to 4000. Careful tests both in England and in this country show that these lamps have at least six times the efficiency as light producers of the ordinary enclosed arc lamps now so generally in use, having a mean lower hemispherical efficiency of one-quarter watt per candle—a truly astounding performance!

The only shortcoming seems to be the frequency of trimming required, seventeen hours being the longest life claimed for one setting of carbons. The carbons are also somewhat more expensive than the old form.

The color of the light is a decided improvement, at least for all cases of exterior lighting, for which these lamps are particularly adapted, over that of the old style arc, being of a golden yellowish hue instead of blue

or violet. Light of this color is far easier on the eyes and much less subject to absorption by a foggy or smoky atmosphere, a point not to be neglected in the lighting of most city streets, as well as of mills and factories. These two very desirable points, namely, higher efficiency and better quality of light, must eventually secure for lamps of this type a practical monopoly of exterior lighting, and in many cases, of the lighting of large interiors.

As the improved incandescent lamps, and also the Nernst, give when used with the proper accessories, an efficiency practically equal to that of the enclosed arc as commonly used with opaline diffusing globes, with the additional advantage of absolute steadiness, and are for nearly all purposes more satisfactory in color than arcs, it seems likely that the present form of enclosed arc lamp, which is the least efficient of all forms of arc light, must gradually give away before these improvements.

The mercury vapor arc has become commercial in the sense of being regularly offered for sale, but in the sense of being a factor to be reckoned with in illumination, it is not as yet of material importance; and it seems hardly likely that it will ever become so, at least unless some method is discovered of improving the quality of the light without reducing its efficiency.

A curious combination of the mercury arc and the ordinary carbon arc is claimed as a practical device by a German electrical company. The device consists simply of an enclosed arc having a quanity of metallic mercury in the enclosing globe, the upper part of the enclosing globe being provided with a condensing arrangement to prevent the escape of mercury vapor from the lamp. The heat of the arc between the carbons instantly vaporizes sufficient mercury to fill the globe, and this vapor furnishes a path for the arc of less resistance than air, with the result that a long luminous arc is produced. It is claimed by the manufacturers that a nearly white light is secured by the use of an amalgan consisting of a slight admixture of other metals with the mercury, and furthermore that the consumption of the carbons is so slow that the lamp will run at least 1000 hours with one trimming, while its efficiency as a light producer is practically equal to that of the Bremer arc. So far as we know, no authorative tests of this lamp have yet been made in this country. The theory, however, seems entirely plausible; and as both the Bremer arc, the tantalum and osmium lamps, as well as the Nernst lamp, originated and became commercial factors in Germany before appearing in this country, it will be well to keep an eye on this latest comer in the field of arc lighting.

Another line of experiments seeking to secure like results with somewhat similar means, and which have been pursued with much care in the laboratories of the General Electric Company in this country, and by Prof. Blondel, in France, are concerned with the use of some other solid than carbon as electrodes for the arc, the most successful combination being copper for the negative, and black oxide of iron for the positive electrode. This combination seems to possess remarkable properties both of endurance and light production. The laboratory results obtained with some of these lamps far outreach even the revolutionary results obtained by the Bremer

arc. Steinmetz succeeded in one case in producing an arc having sixteen times the efficiency of the ordinary enclosed arc. Both Steinmetz and Blondel presented the general theory and results of their work in papers read before the Electrical Congress of the St. Louis Exposition, and anyone interested in this line of investigation will find these two papers invaluable.

Lamps designed for the use of magnetic electrodes have been placed upon the market by the General Electric Company, and, as in the other cases mentioned, the demand far exceeds the supply.

In gas lighting, while there have been improvements in the construction of burners, there seem to have been no innovations of any considerable consequence. The incandescent mantle and burner seem to have been brought to the limit of perfection possible with the present knowledge and supply of materials. The use of chimneys provided with air holes near the bottom has become general on all high-class burners, as has also the use of a sufficiently long mixing chamber to insure nearly the theoretical conditions for perfect combustion. The final step in this direction consists in placing a globe outside the chimney which necessitates the air becoming heated in contact with the chimney before passing in to the combustion area about the mantle, thus furnishing a hot blast for the combustion. By the use of a Holophane globe the light is diffused and directed into the lower hemisphere, thus further increasing the practical useful efficiency of the lamp. This improvement is due to Geo. M. DeGinther, of Philadelphia.

The manufacturers of incandescent gas burners and lamps have been trying assiduously for years to imitate electric lamps, their efforts in the past having been directed mostly toward the simulation of an electric arc lamp. The tendency now seems to be toward imitating the incandescent electric lamp. To accomplish this the scheme of using the mantle in an inverted position is resorted to; and it seems likely that the inverted incandescent gas lamp is to become a factor to be reckoned with in competition with electric lighting. The mechanical difficulties of constructing such a burner are manifestly not easily overcome. To find a practical means of supporting a mantle in an inverted position, and of mixing gas and air in a downward flow and burning the mixture without its "striking back," or burning at the mixer, have perplexed inventors in this line for years. That the difficulties have been so far overcome as to enable manufacturers to offer burners of this type to the public is evidence that the obstacles, if not perfectly overcome, are at least approximately so. It is claimed that burners of this type, by reason of the pre-heating of the gas-and-air mixture before combustion, produce a flame of higher temperature, and consequently a higher efficiency of illumination, than it is possible to obtain with the old form of upright burner; while the freedom from shadow underneath, the more artistic form, and greater adaptability to installations where decorative appearance is important, give them additional claims to the attention of the illuminating engineer.

The desire to assume virtues which one does not possess, to the neglect of those which they do possess, seems to apply to things as well as to man. Thus, the practice of placing an incan-

descent electric lamp in an upright position, and often even with a "candle-cup" under it, is a common method of perverting the virtues of the incandescent lamp in order to imitate the faults of the candle and gas flame; and the cluster of lights in the so-called "gas-arc" lamps, by which one of the strongest advantages of the gas light, namely, its capability of sub-division into small units, is lost for the sake of imitating the worst feature of the arc, which is its generally abnormally high candle-power, and the striving to make an incandescent gas lamp burn upside down, are luminous examples.

The increase in the use of acetylene as a luminant is one of the remarkable features of the year. This growth is particularly phenomenal in the number of plants installed for street lighting. The excellent quality of the light produced, and the possibility of supplying even a house of modest dimensions with this splendid light at a reasonable cost are adequate explanations of the remarkable growth of this industry.

In the case of exterior lighting, however, this remarkable expansion is not so clear, and the growth in this direction must be set down to a considerable extent to the energy and push of the manufacturers of carbide and generating apparatus. In making it possible for even the farm house to have gas light of the finest quality, and with no greater trouble than that involved in the use of an ordinary heating furnace, and at an expense not greatly exceeding that of oil lamps, acetylene has rendered a valuable and peculiarly distinctive service to illumination in general, covering as it does a field which could not be reached either by electricity or ordinary illuminating gas.

While the ways and means of producing light have thus shown remarkable progress during the year, the general awakening to the necessities of better practices in the utilization of light for purposes of illumination has been even more noteworthy. That the various elements entering into the problem of securing the best illumination, with due consideration of both the economic and artistic questions involved, have become so diversified as to place the Science and Art of Illumination among the special branches of engineering, has become generally recognized, both in this country and in Europe. It is especially gratifying in this respect to note that this recognition comes as much from the large industries engaged in furnishing the means of producing light, as from the users of light. While there are undoubtedly still many corporations that look askance of any means of cheapening the cost of light to the user, it may be fairly said that the largest and most influential corporations are among the foremost promoters of illuminating engineering as a special branch of science.

Illuminating Efficiency vs. Candle-Power Efficiency of Electric Lamps

By George Loring

The proper method of rating an incandescent electric lamp has been an open question during many years, and is still undecided. While the rating by mean horizontal candle-power has been accepted commercially by the majority, there are many who have persistently maintained that this measurement as a method of rating was illogical, inadequate and misleading. Even the measurement of mean spherical candle-power which has been advocated fails to recognize the all-important point, namely, the illumination produced—illumination being briefly defined as "utilized light."

With a view to determining the relative illuminating values of lamps having different natural distributions, and thus putting the question to a practical issue, the writer has had made a series of tests, the full report of which, so far as they have been completed, is as follows:—

"The object of this test was to determine the watts of Shelby elliptical coil filament lamps when operated at the candle-power necessary to produce, under stated conditions, upon a certain horizontal plane, an illumination equal to that secured from oval filament lamp of the same nominal candle-power and efficiency. The test was conducted in accordance with instructions of the Shelby Electric Company.

THE CONDITIONS OF TEST.

"Fifty Shelby lamps and 50 oval filament lamps, rated as 16 c.p., 3.1 w.p.c., 110 volts were submitted by The Shelby Electric Company. These lamps seemed normal, and in all particulars fairly representative of the two types. All were measured at their rated voltage. The mean horizontal candle-power and watts of the oval filament lamps and the horizontal candle-power along the axis of the coiled filament, as well as the watts of the Shelby lamps were determined.

"From each group of 50 lamps, the 12 which would most closely approximate their rated candle-power values when burning at 110 volts, were selected and were measured for mean spherical candle-power. As a result of these determinations it was found that the average mean spherical candle-power and watts of the two groups of 12 lamps were substantially identical. Details of these measurements are presented under "Results of Test" in this report.

"Comparable groups of lamps having been secured, a room was selected in which the measurements were to be made. This room is 16 feet long, 11 feet wide and approximately 12½ feet high. The ceiling and walls are of a light buff color, the ceiling construction being steel girder and brick arch. The room has one transparent window and two windows fitted with translucent glass. The first window is 6 feet 11 inches, and the other two are 5 feet 6 inches high. They are of widths indicated in the attached sketch. The floor is painted light red.

"In this room, as close to the ceiling

as was feasible, 12 lamps were placed in such positions as were thought likely to afford fairly uniform illumination on a plane three feet above the floor, which was that selected for measurement. The height of the center of the filaments of these lamps was 9 feet 2 inches above the plane investigated. Their positions in the horizontal plane are as indicated in the sketch previously referred to. All lamps were placed pendant; that is, with the tip downward.

"Eighteen stations were selected for measurement. These were located as indicated in the sketch, 12 being at points directly beneath the lamps and six at points which correspond to the centers of squares formed by groups of four lamps.

"The lamps were operated upon carefully regulated storage battery current. The voltage and watts were measured by Weston standard instruments whose errors had previously been determined.

"The measurements of the illumination were made with the aid of the Weber photometer, an instrument especially adapted to such work. This instrument had previously been very carefully tested and all considerable sources of error eliminated. A special white test plane was constructed which very clearly fulfilled the theoretical requirements. Before and after each test the instrument was standardized by producing on the test plane a known illumination, using a standard lamp at a known distance.

"Throughout the entire test care was taken to provide similar conditions for the lamps of the two types. The illumination upon the diffusing test plane was reduced slightly by the presence of the operator and by the instrument itself. In repeating the measurements for the second type of lamps, care was taken to have the position of the instrument and its operator as nearly as possible coincide with the positions taken in the first test.

"All measurements were made with the diffusing test plane horizontal.

METHODS OF TEST.

"The 12 oval filament lamps, selected as described previously, were placed in the sockets near the ceiling and were held at 110 volts. The total watts of the 12 lamps was noted and the illumination produced at each of the 18 stations in a horizontal plane three feet above the floor were measured. The results of these measurements are shown under 'Results of Test.' These lamps were then replaced by Shelby lamps and the voltage adjusted until approximately the same illumination was produced at the various stations where measurements were made. The lamps were first held at 108.0 volts. The illumination produced at this voltage being found to be higher than that obtained with the oval filament lamps, the voltage was reduced to 107.0 and the measurements were made at that voltage. The total watts of these lamps was observed.

"The accuracy of settings as indicated by a repetition of the work at three stations (the entire process being repeated) was found to be about one per cent.

"The unit of intensity of illumination used in this report is the illumination produced by a source of one candle-power on a surface one foot distant from it, the rays falling perpendicularly on the surface. This has been called the foot-candle."

Results of Measurement of Illumination.

Station No.	Oval Fil. Lamps at 110 Volts.		Shelby Lamps at 107 Volts.	
1	1.62	Foot-candles	1.63	Foot-candles
2	1.86	"	1.92	"
3	1.77	"	1.75	"
4	2.06	"	2.10	"
5	2.04	"	2.09	"
6	2.12	"	1.96	"
7	2.24	"	2.32	"
8	2.08	"	2.15	"
9	2.24	"	2.26	"
10	2.31	"	2.34	"
11	2.11	"	1.98	"
12	2.40	"	2.37	"
13	2.18	"	2.15	"
14	2.29	"	2.14	"
15	2.25	"	2.15	"
16	1.86	"	1.81	"
17	2.16	"	2.07	"
18	2.02	"	1.90	"
Average.	2.09	Foot-candles	2.06	Foot-candles
Total watts consumed.....	610		571	
Watts per lamp...........	50.8		47.6	

Electrical Testing Laboratories.
(Sgd.) Preston S. Miller.
Approved by
(Sgd.) Clayton H. Sharp,
Test Officer.

P.S.M./P.
Nov. 27, 1905.
Checked by E. F.

Reducing the results to a percentage basis, it appears that the oval anchored filament type of lamp required seven per cent. more current than the Shelby type in order to produce an equal illumination, and, at the same time, the difference in current caused the oval filament type of lamp to run at a higher temperature, which will produce a shorter life. According to the best data obtainable, which has been gathered from a large number of tests, to determine this law, the relative useful lives of the different style lamps, would be in the ratio of nine to five. If the lamps were run at equal efficiencies, there would be much greater gain in favor of the Shelby type of lamp in respect to total consumption of current, as the oval anchored filament lamp would require sixteen per cent. more current to produce an equal illumination.

It is to be noted in the results obtained that the walls and ceilings of the room in which these measurements were made were of a light tint, causing a reflection probably above that produced under average conditions of illumination, which is proportionately advantageous to the oval filament lamps. Nevertheless, this reflection from the walls did not aid in the illuminations to the extent that would be expected, which goes to prove that the reflecting efficiency of walls has undoubtedly been overvalued.

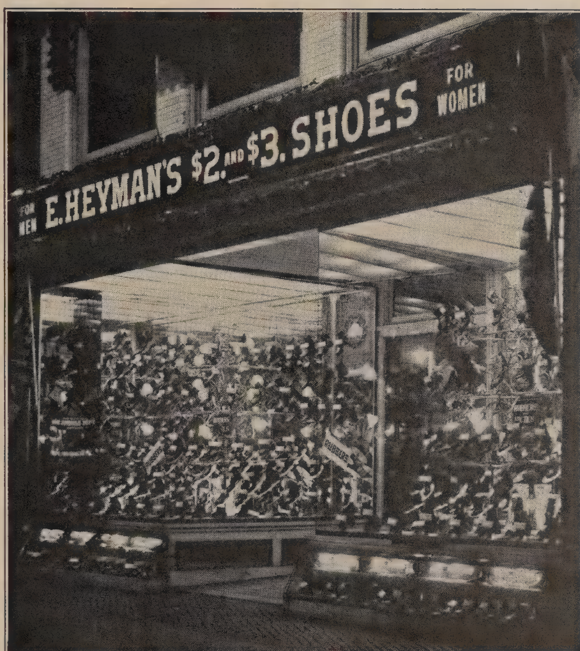
It is often urged in regard to the advantages of a natural downward distribution, that it is better practice to construct a lamp regardless of its natural distribution and depend upon reflectors for directing light. This may be true in some cases. There are, however, many places where the use of accessories for redirecting the rays of light is impracticable, and in some instances objectionable under two general conditions: First—when the presence of dust or smoke prevents the accessory from performing its work efficiently, and, second, when an accessory is incompatible with the decorative or architectural conditions involved. In the first instance may be mentioned mills, factories and other similar cases, where not only the presence of dust would necessitate additional labor in keeping the accessories clean, but where breakage would also be an item. Cases in which the lamps are inaccessible, as on high ceilings, where accessories could not be readily reached to be cleaned, would come in

the same category. It is often desirable to use lamps studded in the ceiling, where a reflector or other accessory would be entirely out of harmony. In all these cases, therefore, the natural distribution of the lamp is of primary importance. Finally, it should not be forgotten that accessories for diffusing or directing rays of light are at least as advantageous to the Shelby type lamp as to the Oval Anchored Filament.

A New Method of Show-Window Lighting

By Paul H. Jaehning.

A novel method of show-window lighting, which is a radical departure from conventional methods, is shown in the illustration below. The windows are entirely of glass, as shown, and measure about 8 feet wide by 9 feet deep, with a height of about 8 feet from the bottom of the window to the glass top. About 12 inches below the ceiling of the window there is placed a false ceiling of ribbed glass supported by a slight metal frame work. About this glass are installed sixteen 50-c.p. G. E. units, the bottom of the lamp coming within about 3 inches from the glass. The lamps are provided with Pagoda reflectors and are not frosted. The lamps are wired on 3 switches in each window so that one-third, two-thirds, or all may be used, as desired.



The result of this method of illumination is a very completely diffused light throughout the entire space in the window, with a noticeable absence of shadows, and a light very much resembling sun light in brilliancy. The window has excited very favorable comment among engineers who have seen it, who express the opinion that it is the ideal method of show-window illumination.

Actual Results in Illumination

As Compared with the Results Obtained from Mathematical Formulas

The basis of an engineering problem is always to be found in mathematical formulæ. The successful solution of the problem, however, requires both judgment and skill in the use of these formulæ. This necessary judgment and skill must be acquired by experience, in order to determine wherein the practical conditions modify the purely theoretical. As illuminating engineering is the youngest of the specialties, it is particudarly desirable that all data relating to the discrepancies between theory and practice be recorded, so that the engineer may not be put to the necessity of experiments and possible information that others have gained.

In starting to lay out a system of illumination, the fundamental fact to be determined is the intensity of illumination desired on some assumed plane or surface. This determination is wholly one of judgment. Having determined this, the kind of light-sources to be used, the accessories for directing and diffusing light, and the position of the units may then be determined. The intensity of illumination in foot-candles may be predetermined with a comparatively high degree of accuracy, with the exception of the factor of reflection from walls and ceiling. This factor is difficult to determine with accuracy by mere calculation, as it depends upon the coefficient of reflection of the walls and ceiling, modified by the number and position of doors, windows, furniture, etc., and therefore contains a number of variables. The theoretical coefficient is obtained from the formula

$$K = \frac{1}{1-C}$$

in which C is the coefficient of reflection of the walls. In the case of white plaster walls, which may have a theoretical coefficient of reflection of .50 to .75, it will be seen that the value of K becomes very considerable; thus if C = .50, the value of K becomes equal to 2; that is the reflection from the walls would double the illumination. Actual measurements of illumination, however, by means of an illuminometer show a very much lower value for K than that given by the formula.

A series of very interesting and valuable experiments to determine both the actual value of K under given conditions, and the discrepancies between calculated and actual illumination have been carried out by Mr. O. M. Rau, Superintendent of the Electric Lighting Department of the Milwaukee Electric Railway and Light Company. This company has recently erected one of the most complete—in fact, probaby *the* most completely equipped office building and terminal station for a street railway that has ever been constructed, it being one of the very few buildings in which the illumination throughout has been treated as an engineering problem, and laid out not only in accordance with theoretical principles, but where the

theoretical principles have been untried in practice, experiments have been conducted to check up the actual results. The following details are taken from the report made by Mr. Rau to his company:

"The values of illumination, in the rooms shown in Figures 1, 2, 3, 4 and 5, are compared in Table I with the theoretical values first determined. It will be seen, by referring to Table I, that these theoretical results are too high. This is due partly to the fact that K, the constant of reflection, was assumed too high, and partly to the fact that the distribution curves of the lamps were not used, neither was the angle of incidence of the light with the illuminated surface considered; the illumination was computed by assuming the distribution of light to be uniform, without considering the angle of incidence of the light with the illuminated surface, and by assuming K to be 2.5. Consequently new theoretical values were computed for these rooms, taking into account these various factors. These results, shown in Table I as 'corrected theoretical' foot-candles, compare much more favorable with the actual results.

"The value of K used in calculating the 'corrected theoretical' values was obtained in the following way:—Room No. 343 was lined with tar paper and the illumination at several points was measured by means of the illuminometer; then the tar paper was removed and the illumination at the same points was again measured. The ratio of the illumination in the room with white walls to that in the room when lined with tar paper gave the actual value of K. K, obtained in this way, is probably smaller than it should be, due to the fact that the tar paper was not a jet black and was somewhat glossy. The result, however, must be nearly correct.

"It is interesting to note, from Table II, that there appears to be a difference in the value of K in different parts of the room, due to irregularities of reflection caused by doors, windows, etc. It will be noticed that K is small directly under the East lamp because of the poor reflection from the door and windows in the East wall, while in the corners, where there are two adjacent white reflecting walls, it is higher. The data, however, is not sufficient to determine this point definitely."

TABLE I.

Showing Comparison of Theoretical Values of Illumination and Values as Measured by G. E. Illuminometer.

No. of Room.	No. Lamp.	Rated c. p.	Theoretical foot-candles per report—Table 12.		Corrected foot-candles. Theoretical.		Actual foot-candles as tested.	
			Max.	Min.	Max.	Min.	Max.	Min.
341	6	75	5.33	3.00	3.15	1.46	3.20	2.52
342	4	50	2.75	1.49	1.98	.64	1.64	.58
343	5	50	3.55	1.95	2.10	.99	1.90	1.24
344	5	100	7.30	3.80	4.84	1.76	4.72	2.74

In room No. 342 Nernst lamps were used; in all other rooms G. E. high-efficiency units.

TABLE II.

Showing Value of "K" as Derived from Tests.

Room 343.

Foot-candles. Light.	Foot-candles. Dark.	K.	Remarks.
1.39	1.82	1.70	In northeast corner—Good reflection walls.
1.62	1.15	1.41	Under east lamp—Opposite door and windows poor reflection.
1.90	1.25	1.51	Under south Middle lamp—Opposite door reflection not good.
1.88	1.16	1.63	Midway between four lamps—Center of room.
1.86	1.20	1.55	Between south lamp and away from wall—Good reflection.
1.54	1.01	1.52	At south wall between lamps—Good reflection.
1.90	.99	1.93	Under northwest lamp—Opposite window, but other wall white.
1.24	.67	1.85	In southwest corner—On reflecting wall.

Average 1.64

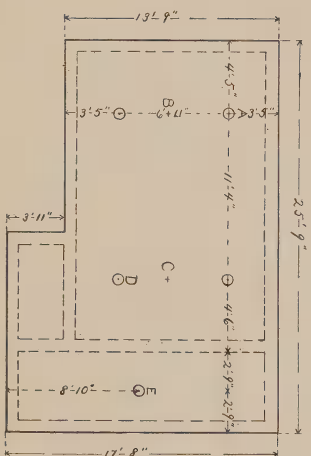


FIG. 1.

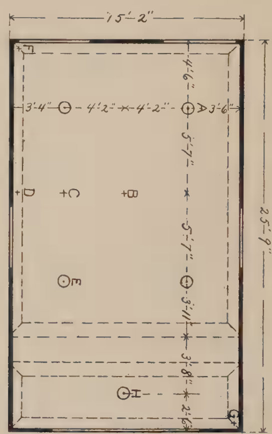


FIG. 2.

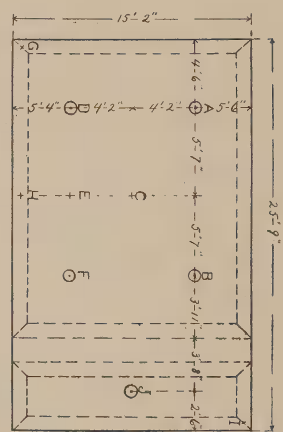


FIG. 3.

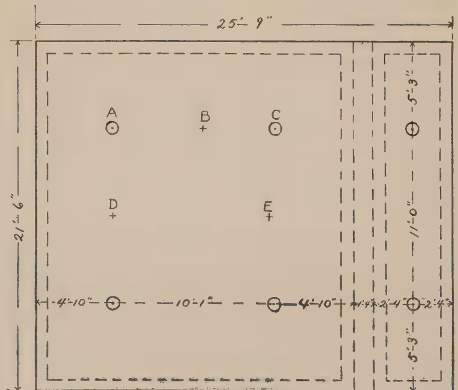


FIG. 4.

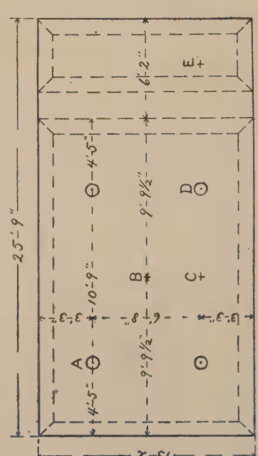


FIG. 5.

In a paper on the "Engineering of Illumination," read before the Western Society of Engineers, Mr. V. R. Lansingh cites an example of a church in which the illumination was predetermined very carefully, taking into account the changes of distrbution effected by the use of particular forms of globes, and the coefficient of diffusion. The results of the actual illumination obtained, measured by an illuminometer, are surprisingly close to the calculations. Mr. Lansingh says:

"An example of the precision which can be obtained is the illumination of a church by Prof. Smith. The illumination at 83 points of the church, both on the balconies, on the main floor and under the balconies, was calculated beforehand and later measured by an illuminometer. The mean per cent. between the measured and calculated values was 6.6, the maximum being 27.2 and the minimum 0.0, the higher figures being due to certain lights which were added after the calculations were made. These results show what it is possible to do in the way of exact calculation of illumination. * * * If the room is of any considerable size, this factor (k) becomes in many cases practically unity, while if the decorations are light, it may rise to 2 or 3 or even higher, depending on the conditions. It is, therefore, necessary to carefully consider this factor. In the case before mentioned of the calculations of the church, this factor was 75 per cent., and the fact that the mean results only differed about 6 per cent. from the calculations, shows how carefully this factor was determined."

The Life of Incandescent Electric Lamps

As a Factor in Efficiency of Illumination

By Preston S. Miller

In connection with the engineering of illumination every effort should be put forth to secure for the light-sources the longest life consistent with efficiency.

Particular insistence must be placed upon this when incandescent electric lamps are used. Three factors in particular must be considered. These are voltage regulation, condition of burning, and size of lamps used.

As affecting the voltage regulation the calibration of voltmeters used in establishing and maintaining the regulation is important. In order to appreciate this, one has only to remember that a variation of one per cent. in the pressure at which the lamps are operated occasions a variation of about 15 per cent. in the life of the lamps.

Voltmeters of precision may be obtained in the market. The best of them, however, should be watched closely, while those which are not so good should always be regarded with suspicion. Laboratory standard instruments which are not used as portable instruments retain correct calibration for a long period. Nevertheless in both standard and portable types the difficulty which is to be apprehended is a subtle, insidious change likely to escape detection and fraught with serious consequences. The best way of insuring the detection of such a change is to check the indications of the instrument systematically and periodically against a standard of known authenticity. For this purpose reference should be had preferably to the potentiometer and standard cell. These may be obtained in a variety of forms, ranging from the instrument of high precision and wide range, adapted for work in experimental laboratories, to the simple, portable instrument designed to check a voltmeter at a few points, with a fair de-

gree of accuracy. When a potentiometer is not available, one voltmeter should be set aside to serve as a standard. To this all instruments in use should be compared periodically. By intercomparison, change in any one of the instruments may be detected. One may then feel sure of his instruments, where only approximate accuracy is desired, if he sends the standard instrument to a laboratory to have its indications verified upon stated occasions and in every case where the comparison with other instruments indicates a change.

The second factor suggests one fault to be found with the practice of some illuminating engineers. It is a tendency to devote almost exclusive attention to the placing of the light, and the appearance of the source and its accessories. Neglect of care in providing proper conditions for the sources of light has sometimes serious consequences. Frosting lamp bulbs, enclosing electric incandescent lamps in globes of some types and placing them in positions where heat is likely to be confined, all tend to decrease their useful lives.

A third point which should be remembered is that in the selection of the unit to be used in a lighting installation, the life of the lamps forms a consideration. In many instances, engineers determine the size of the lighting units by convenience in locating them and in the selection of accessories, without regard to differences in life values characteristic of the different size units. A 50-c.p. electric incandescent lamp may have a life which is much shorter than that of a 16-c.p. lamp; but too often this consideration is entirely neglected.

It is hoped that in the deliberations of the new Illuminating Engineering Society, emphasis may be laid upon the necessity of these considerations and that much of value may be brought out in its papers and discussions bearing on this subject.

The Illumination of the Hotel Astor

New York City

From "The Central Station," November, 1905.

There are usually several ways of doing a thing well, and an infinite number of ways of doing it badly. If left to chance, therefore, it is nearly always done badly. A thing done well is *prima facie* evidence of study and care exercised in its doing. The illumination of the Hotel Astor is remarkably done well; and the philosophical observations just made apply with full force.

To be explicit; it is doubtful if there is another building of any kind in this country in which the illumination has been so carefully considered in all its phases as in this case. The building is one of the latest additions to New York's mammoth and magnificent hotel structures. It fronts the entire block on Broadway between 44th and 45th streets and is a parcel of the property belonging to our late countryman, Wm. Waldorf Astor. The exterior appearance of the building speaks well for the general ability of the architects, Messrs. Clinton & Russell, as will be seen by a reference to the illustration. The interior is designed to meet every requirement of the modern hotel, including various dining rooms and cafés, ballroom, special assembly rooms, and probably the finest roof garden of the kind in the country. The problems involved in the interior illumination are therefore varied, and offer correspondingly great opportunities for either blunders or artistic effect.

The original installation was designed on

a lavish scale, in accordance with the general high character of the building; but as so frequently occurs in such cases, when the building was put to its destined use, it was found that in many respects the illumination was absolutely inadequate, and in practically all cases could be improved, either in regard to economy, or quality, or both. The whole subject, therfore, became a matter of continuous thought and study on the part of Mr. F. A. Muschenheim, with the result that many changes have been made, and others are still to be carried out. In this work he has had the cooperation of Arthur A. Ernst, a competent illuminating engineer of this city.

While the limits of this article will not permit of a general detailed description of all the illuminating appliances and methods used, an examination of some of the principal effects and defects will be instructive.

The lobby is formed by two halls 100 feet long crossing at right angles. The main, or Broadway entrance, and the "Orangerie" form the terminals of one of these halls, while the ladies' dining room and the gentlemen's café are at either end of the intersecting hallway. The ceilings are 20 feet high, and laid out in heavy paneling with gilt finish. A gallery runs along the rear of the intersecting hallway. The lighting of this lobby is by means of seven bowls of glass beadwork 36 inches in diameter, suspended 18 inches from the ceiling, and twenty 12-inch bead work spheres. There are also five Holophane bowls under the galleries. As bead work absorbs over half of the light, it was found that the original installation, consisting of twenty 16 c. p. lamps, in each of the bowls, did not give sufficient illumination. Mr. Muschenheim hit upon the ingenious device of placing Pagoda reflectors inside of the bead work bowls, and in this way succeeded in so increasing the illumination below, that he found it possible to replace the twenty 16 c. p. lamps with four of the new 50 c.p. high efficiency lamps of the General Electric Co. Assuming the 50 c.p. lamps to use 125 watts, this change effects a saving of 4,340 watts in the seven fixtures; but what is even more to the point, the illumination is now entirely satisfactory. The 12-inch balls were supplied with 8 16 c.p. lamps, also fitted with Pagoda reflectors. These have been replaced with one 50 c.p. high efficiency lamp and reflector, which effected a saving of 4,952 watts in the sixteen fixtures; making a total of 9,252 watts, or 12½ horse-power saving in the lobby alone.

The ladies' dining room, shown in the illustration, has the same height of ceiling and is a rectangular room 68 feet long and 30 feet wide. This room was originally lighted with fourteen large bead work balls, attached directly to the ceiling. Each of these balls was supplied with eighteen 16 c.p. lamps. While these were intended to furnish the general illumination of the room, side brackets carrying small incandescents were provided for the sake of the decorative effect, and by increasing the number of light sources to add to the general cheerfulness of the room. To increase the illumination the same expedient was used in the lobby; the 16 c.p. lamps were replaced with six 31 c.p. lamps in Pagoda reflectors. Recently, also, the bead work bowls have been removed from the ceiling and dropped about six feet by means of heavy chain supports. This is an undoubted improvement, as it increases the illumination upon the tables, and reduces the light on the ceiling. Mr. Muschenheim is firmly of the belief that ceilings in all cases should be kept perceptibly darker than the lower portions of the room; and the results of his experiments in this direction certainly justify his belief.

The gentlemen's café (Hunting Room) at the opposite end of the hallway, has a novel and very pleasing arrangement of the lamps. As shown in the illustration, there are twelve chandeliers constructed entirely of elk horns, at the various points of which 2-inch spherical frosted lamps of 8 candle-power are provided, each chandelier supporting about 20. There are also 22 side brackets carrying six frosted 16 c.p. tubular lamps. The large number of lights, and the originality of the fixtures, which are in such harmony with the spirit of the place, produce a most satisfactory impression.

In the rear, and opening directly into the lobby, is a dining room which is called the "Orangerie," a name which is somewhat inappropriate at the present time, as the original decoration of orange trees in full fruit has been entirely removed. The room,

THE "HUNTING ROOM" (GENTLEMEN'S CAFÉ).

however, is one of the most attractive dining rooms in the city, and the lighting most unique. It is impossible to give an idea of the general beauty of the room and its illumination by any written description. The ceiling of the central portion of the room is laid out in deep panels between the supporting pillars. Across each panel there are a number of small beams a short distance below the upper surface; these are in the form of a trough on the upper side, and in these troughs, which completely hide them from view, are placed 16 c.p. lamps in Pagoda reflectors, the open end of the reflector being provided with a green tinted transparent screen. Thus a delicate green light is cast upon the ceiling above. The beams are also overspread with grape vines, giving to the whole the appearance of a magnificent grape arbor. From the main beam of the ceiling are suspended by drop cords a total of one hundred and forty-three 16 c.p. lamps in Pagoda reflectors covered with grape leaves, so as to entirely hide both reflector and lamp. These furnish the illumination for the tables. At each end of the room the ceiling is raised into tunnel vaulting, which has cathedral glass set in the panels. Above the glass a number of Cooper-Hewitt mercury arcs are placed, which give a remarkable simulation of moonlight. A gallery runs entirely around the room. On one side of this gallery the walls are decorated with finely executed mural paintings, which are lighted by concealed Frink reflectors. The illumination of the gallery, which is also furnished with tables, is by 16 c.p. lamps suspended on short cords and covered with wistaria blossoms. A small fountain with statuary faces the main entrance, and this is lighted with a Cooper-Hewitt lamp. The only visible light sources are a few 16 c.p. lamps colored a delicate rose tint, and covered with Pagoda reflectors, placed on side brackets.

Occupying one corner of the first floor, and opening directly into the Orangerie, is a room intended originally as a billiard room, but now used as an extension of the café, and known as the Pompeian Room, from the style of the decorations. The room is fitted with five peculiar fixtures, which may be described as inverted umbrellas made of metal and heavy cathedral glass. They were dropped to reach within eight feet of the floor, and presumably were intended to light the billiard tables. Each was supplied with twenty 8 c.p. lamps, which, due to the peculiar construction of the fixtures, threw most of the light toward the ceiling, illuminating it very slightly. By substituting 4 32 c.p. Sunbeam lamps, which make of lamp is used exclusively throughout the entire hotel, with Pagoda reflectors, the conditions were reversed and the desired results obtained. The general illumination of the room is completed by eighteen side brackets, and three opal bowls on a portion of the ceiling, that is lower than the main body of the room. The brackets are provided with two upright electric lamps and Holophane globes.

In the buffet there were originally thirty-six 16 candle-power bare lamps, studded about a large panel in the ceiling. These have been replaced with 8 candle-power lamps and small Pagoda reflectors, with the result that the illumination on the bar is much better than before. There are also about the room eight 5 light brackets fitted with 8 candle-power frosted spherical lamps, and three frosted glass bowls each supplied with four 16 candle-power lamps on a portion of the ceiling that is lower.

In the basement, reached by a broad stairway from either end of the lobby, is the American Indian Grill Room. This room is 22 x 100 feet, with a low vaulted ceiling. In the original installation, lanterns, or balls, made up of smoked mica set in an iron frame work, were attached to the intersecting points of the vaulting, each containing eight 16 candle-power lamps; but even with this excess of light the absorption of the smoked mica was so great that the tables were in comparative darkness. These have been replaced with a small neat iron fixture having six pendant 8-candle-power lamps with small Pagoda reflectors. The result is an illumination that is practically perfect for the purpose, being perfectly uniform, and the sparkle of the light in the reflector adding a cheerfulness to the room that can be obtained in no other way. When the lanterns were removed, it was found that the insulation on the wiring was charred and brittle, in some cases to such an extent as to make short circuits, due to the excessive heat from the numerous lamps.

THE "ORANGERIE."

The light-sources are entirely hidden from view, being placed under reflectors covered with leaves, and above the glass in the domes.

THE LADIES' DINING ROOM.

The bead spheres have been suspended by chains six feet from the ceiling, which has materially improved the general effect.

Above the landing of the stairway leading to this room, there is a handsome wall painting. This was originally lighted with two 16-c.p. lamps in a mirror-lined trough reflector, such as is frequently used for such purposes. This has been replaced with a single 16-c.p. lamp in a Pagoda reflector with cardboard shade, and the illumination of the picture is perfect. This shows how carefully every detail in the lighting has been examined and improved where possible.

In the hallways leading to this room there were originally 10 and 12-inch frosted globes containing five 16-c.p. lamps; these are now supplied with one 75-c.p. high efficiency lamp, which gives much better results.

The ball and banquet room is on the eighth floor, and is 75 x 55 feet, with high ceiling. The decorations are in light tints and gilt. The illumination is by means of eight chandeliers, or rather large bowls of bead glass work, with a festoon of bead glass above them, and suspended from the ceiling to within ten feet of the floor. Each of these chandeliers is provided with thirty-two 16-c.p. incandescent lamps distributed in the bowl and within the festooned bead work above. Within the window casing at the side, a number of lamps are also installed which light the curtains and thus add greatly to the appearance of brilliancy to the room. These lamps are entirely out of sight.

At the other end of the main hallway on this floor are a number of private dining or assembly rooms, finished in different characteristic forms of decoration. The largest of these is called "College Hall," the wall decorations representing various scenes in the game of football. The illumination was originally by bead work bowls containing twenty 16-c.p. lamps; but these have been reduced to twelve lamps with Pagoda reflectors.

The hallways leading to the rooms have been the subject of special care on Mr. Muschenheim's part. As the doors are provided with transoms, great care has been taken to prevent light from entering the rooms. The lighting is by means of side brackets furnished with two pendant lights. In order to reduce the light in the rooms, the lamps were first cut down from 16 to 8-c.p., and finally the brackets have been supplied with Pagoda reflectors, having paper shades on the outside, so as to entirely cut off the upward light. By this means the floor of the hallways is lighted sufficiently to make passage through them easy, while practically all direct light is cut off from the ceilings and thus prevented from entering the rooms.

The rooms themselves are the best lighted we have ever seen in a hotel. Their average is 11 x 19 feet. The general illumination is by a three-light chandelier placed very near the ceiling, the three lamps being fitted with Pagoda reflectors, as shown in the illustration. This gives a practically uniform illumination throughout the entire room; and to provide special illumination a two-light bracket, also fitted with reflectors, is placed above the dresser, and table lamps for writing and reading. One of these table lamps is fitted with a Hylo lamp which can be used as a night lamp for those accustomed to a faint light in their room during the night.

GUEST ROOM.

The top of the building is used during the summer as a roof garden, being fitted out in the style of an Italian garden. The

artificial light here has purposely been kept very dim, so as not to obscure the magnificent view of the city, the river and the Palisades beyond, which affords a panorama of unsurpassed beauty. This remarkable garden is furnished with an abundance of growing shrubbery, banks of blossoming plants, and cascades of running water. The top of the building is outlined with a double row of large globes on pedestals, as shown in the illustration of the building. A similar row of pedestal lights is also placed along the inner edge of the sidewalk. Where these originally contained eight 16-c.p. lamps they are now supplied with one 75-c.p. high efficiency unit, with far better illuminating results. The frosted globes have also been replaced with opaline, which does not collect dust and show soil like the ground glass.

Taken altogether, this building furnishes perhaps the best example of the practical advantage of handling illumination as an engineering problem. The primary object in the changes was to improve the illumination, which in many cases was so unsatisfactory as to make a change imperative; but it is especially worthy of remark that in every change made, not only has the illumination been brought up to a satisfactory condition, but a material saving in electric current has been effected at the same time. While this saving in current may not show so plainly in the running expenses as it would were the current being purchased by meter, nevertheless the reduction throughout the building when all changes have been made, will be so large as to readily make itself felt in the coal bills.

The question also arises, in case a building, presumably constructed in accordance with the most advanced modern ideas and with the best of equipment and construction, proves a failure in so important a respect as artificial illuminations, as to where the responsibility is to be placed. Evidently not with the electrical engineers, for the means of generating the current and of supplying it where required, seem to be entirely satisfactory. The fault must then be laid to the doors of either the architects, or the decorators—if the decoration was given as a separate contract. The simple cost of the changes that have already been made, to say nothing of the economies that will be continuous hereafter, would amount to a very respectable fee for a consulting illuminating engineer. Thus, what Stevenson said of the mechanical engineer will hold equally true of the illuminating engineer: *"The services of a competent engineer are not an expense, but an economy."*

THE ILLUMINATING ENGINEER

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FOREWORD

In presenting the first issue of a new publication to the public, it is fitting that its general aim and purpose should be briefly set forth.

THE ILLUMINATING ENGINEER will be primarily a Technical Journal. There is a well-defined difference between the Technical Journal and the Trade Journal. The former is a medium for disseminating scientific knowledge and technical data, and aims to keep its readers posted on the discoveries and advancement in knowledge in the particular field which it covers; while the latter seeks to present to its readers useful information relative to the practical and commercial sides of the particular art or craft with which it deals. We say that this publication will be primarily a technical journal, as we believe that there is an actual need and demand for a greater general knowledge of the scientific principles involved in the use of light for purposes of illumination; at the same time the economics of the subject will by no means be neglected. The title is intended to recognize and emphasize the fact that the science and art of illumination deserves to be ranked among the special branches of engineering, and engineering in any branch requires consideration of both the scientific and economic aspects of the problems involved.

Along with food, clothing, and heat, artificial light is one of the commodities which every civilized human being uses every day; and the degree of civilization of a nation or people is fairly indicated by the extent to which artificial lighting is used. It is a remarkable fact that, while the *production* of artificial light receives attention commensurate with its importance, and has several periodicals devoted exclusively to its various branches, there is not at the present time, to our knowledge, a single publication devoted to the *use* of artificial light, or illumination.

The means of producing light from various sources, such as electricity, illuminating gas, etc., will receive a due amount of attention, as will also improvements in accessories and apparatus for distributing and diffusing light after it is produced. All progress in this field in the way of new methods or devices will be recorded and diffused without prejudice or partiality. The Illuminating Engineer need not necessarily concern himself with the production of electricity, gas or other luminants, but must be familiar with the means of converting these luminants into light, and the utilization of the light produced for purposes of illumination.

The money expenditures involved in the production and use of light are enormous; and it is safe to say that in no other department of modern

commerce is there so much expended with so little knowledge of the best methods of obtaining the desired results. In the vast majority of cases, the expenditure is made without accurate knowledge or due consideration of the scientific principles involved, or the results which measure the actual return for the money expended. If "he who makes two blades of grass grow where only one grew before, is worthy to be considered a benefactor to his race," then also he who devises means whereby a result which previously required an expenditure of two dollars can be obtained for one, or even for one dollar and ninety-nine cents, is likewise worthy of respect. In the use of light, wastefulness of means and inadequacy of results are the rule, not the exception; a condition due solely to ignorance and lack of appreciation of the vast strides that have been made in both the means of producing and utilizing light, and the diversity of conditions involved. To work toward removing the causes of this unseemly condition constitutes the sum total of our aims.

One of the special features of this publication will be the study of individual problems, showing the practical application of the technical and scientific principles of the subject, with the due consideration of the economics of the problem.

Illumination is an art as well as a science. The production of artificial light necessitates mechanical devices and fixtures which must be exposed to view to a greater or less extent. They therefore become proper objects for the application of applied or decorative art, and thus must engage the attention of the architect and interior decorator. Cases in which the decorative consideration of the lighting have resulted in distorting the real objects to be sought, which are primarily utilitarian, are so frequent as to need no special examples. The artistic side of the subject will, therefore, receive its due attention in our columns.

The use of artificial light is for the purpose of enabling us to see objects. Seeing involves the use of the organs of vision. To secure the most satisfactory results a knowledge and consideration of the action and care of the eyes; in fact, this forms the real basis of illumination as a science. It will be our purpose to set forth these principles in accurate language, stripped as far as possible of all technical terms that are unfamiliar to the average reader. All of these points might be treated in a single volume rather than in a serial publication, were it not for the fact that, in common with other fields of scientific activity, continual progress and improvement is being made in both the means of producing and of utilizing artificial light. Furthermore, new conditions and problems are continually arising, the consideration of which in their proper season can be accomplished only by a publication appearing at frequent intervals.

In conclusion, it is believed that a publication of this scope is justified, not for the reason that there may be a chance for it to secure a sufficient amount of patronage to make it financially profitable, but because there is an actual demand for the particular information which it will seek to give.

The American people are undoubtedly the most liberal spenders in the world, and the cheapening of any one particular commodity results either in

the purchase of a greater amount of the same commodity, or of other commodities. This is forcefully exemplified in the case of light. Where our grandfathers contented themselves with the light of a single tallow dip, we of to-day require a dozen gas or electric lamps. It is furthermore a truth so patent as to be practically axiomatic, that the dealer who gives the greatest satisfaction to his customers will, in the long run, reap the greatest profits. There is no one method of producing light that has a monopoly at the present time. The user of electric lights who purchases his current from a central station has always the alternative of generating his own current, or even of using illuminating gas in place of electric light; while conversely, the regular user of gas light can either turn to electricity, or establish his own gas works in the shape of an acetylene generating plant. It is therefore an unsafe and untenable position for any lighting industry to attempt to suppress or discourage improvements in illumination, even though they may apparently, and possibly even actually for the time being, reduce the receipts from consumers.

The most cursory glance over the history of the lighting industry will show that methods of reducing the cost, or improving the quality of light, instead of diminishing the income of lighting companies, have invariably increased it by increasing the general use of light. A single example will illustrate: When the incandescent electric lamp, as a successful commercial article, was first announced by Edison, it created nearly a panic in the stocks of gas companies throughout the world. While the average selling price of gas has been reduced to practically half of what it was at that time, and while the use of electric lighting, particularly by means of the incandescent lamp, has become one of the great industries of the country, the production of illuminating gas has at the same time been steadily on the increase, and profits continue to be satisfactory to the companies.

The instinct which impels one to attempt to suppress a new specialist in the arts and sciences is probably a special manifestation of the general truth that "self-preservation is the first law of nature." The appearance of the illuminating engineer as a new specialist among the already numerous specialists of the present time, brings this tendency to light. The electrical engineer, now so numerous and common as to arouse no more comment on account of his calling than the civil engineer, is nevertheless, of very recent origin; the first electrical engineer must still be a comparatively young man. But this is a rapid age, and there are those to-day calling themselves electrical engineers that assume that, by virtue of their title, they have a monopoly on electricity and all its works, and therefore resent the illuminating engineer as a trespasser on their particular preserves. Happily, however, the number of such is few, and will diminish to the vanishing point within a short time.

In the architectural profession, while the same condition exists as to the assumption of monopoly on nearly all departments of human knowledge, the recognition of illuminating engineering is by no means general. It is only fair to state, however, that by the very nature of an architect's work, he re-

quires a very great diversity of information and skill, and also, for the same reason, the claims upon his attention from the various industries represented in supplying the innumerable elements that make up a modern building, are greater probably than in any other profession, and hence his failure to give to the subject of illumination the attention which the illuminating engineer deems necessary can be more readily condoned. In this respect also it is pleasant to note a very great change, even within the past year, and at the same rate of progress it will be but a few years before the illuminating engineer will be so generally recognized by the architect as a consulting specialist as is the electrical engineer, or construction engineer, at the present time.

While there has been for a comparatively long time, at least since the introduction of the electric lamp, a more or less general recognition of the crudities and absurdities in the practice of illumination, and desultory groping after better methods, it was not until the past year that these tendencies crystalized into a positive demand for Illuminating Engineering as a distinct branch of applied science. As the technical press may be assumed to fairly represent the conditions in the engineering field, the following extracts from editorials will be of interest as bearing on this subject:

ILLUMINATING ENGINEERING

From "The Electrical Review."

Attention has been called several times to the new art of illuminating engineering. The art, however, is not new, but it is only of late that its importance has been recognized. Heretofore when a building was to be lighted the work was generally delegated to some one who had made a specialty of running electrical wires or gas pipes, rather than one who had made a study of illumination and the best way to get it.

There is a system of illumination best adapted for every particular room, and there are few occasions in which it would not be advisable to get the advice of some one who has made a specialty of lighting before carrying out the work. To many the lighting of their homes may seem too trifling a matter for expert advice. Viewed perhaps from the standpoint of the first expenditure this might be admissable, but every one should remember that economy in service is just as important as first cost; and more important than either is a satisfactory result, for upon it depends not only the comfort of those who frequent the rooms, but even their health.

There are doubtless many who do not know that there are men who have made a specialty of this work, but there are more who do not realize how far this art has been carried. To-day the illuminating engineer studies not only the best degree of lighting required for every room, bearing in mind for what intended, but he studies the best method of getting it; he is familiar with the characteristics of the different illuminants, and can say which will give the most saitsfactory results in any case. And this is true not only with regard to the degree of illumination desired, and the direction in which it shall come, but also of the quality of the light. The illuminating engineer is to-day prepared to meet all such requirements and to advise as to the best method of lighting streets and buildings, in each case giving due consideration to the particular conditions which prevail. This class of work should appeal particularly to the electrical supply companies and to architects: to the first because it assists them materially in giving satisfactory service; to the latter because of the aid which it brings to them in their work. Poor lighting frequently upsets the most careful work of the designer of the building.

The position of the illuminating engineer would seem to be pretty well assured, and one may hope that as his value is recognized and his services more and more employed that the result will be plainly noticeable.

WANTED; A NEW SPECIALIST

From "The Electrical Review" (London).

To-day is the age of specialization, and electrical engineering has fallen into line with other callings. It is impossible for any one man to cover intelligently the whole subject of electricity supply, and hence the need for specialization and appeal to the authority of the consulting engineer has arisen. It is, however, a curious circumstance that, whereas the methods of generation and distribution have been parceled out into special subjects, the actual object of the process—illumination of premises—is often left either to the decorator, the architect, the fittings manufacturer, or the non-technical owner of premises. The borough electrical engineer and his assistant sometimes offer well-meant advice, but, being more intimately connected with the heavier branches, they have not sufficiently studied the subject of illumination to be ranked as specialists. There is now a field for a specialized illuminating engineer whose consideration should be directed to such points as the following: The position, grouping, shading and reflecting of lights; the installation of circuits to obtain the maximum number of lamp-hours per equipment; the æsthetic arrangement of the lighting in public buildings, such as art galleries, theaters, and churches, and economies connected with the selection and renewal of incandescent and other types of lamps.

That such an engineer is required, can be seen by noting the defects in lighting found at present in public and private installations. Lamps are hung so as to be unavoidable by the eye, and are hence most irritating; at the other extreme we have lamps so densely shaded that the bulk of the light paid for is wasted. The grading of illumination is improperly carried out. The same candle-power per unit area is found in the library, the dining-room, and the billiard-room. Probably much of the opposition to the Wright demand system is due to the presence of the large excess of lamps over those continuously necessary, in installations equipped by persons unacquainted with the elementary principles of economical and effective illumination. The benefit conferred both on the consumer and the supply authority by his labors would be immense.

A SUGGESTION FOR INCREASING CENTRAL STATION BUSINESS

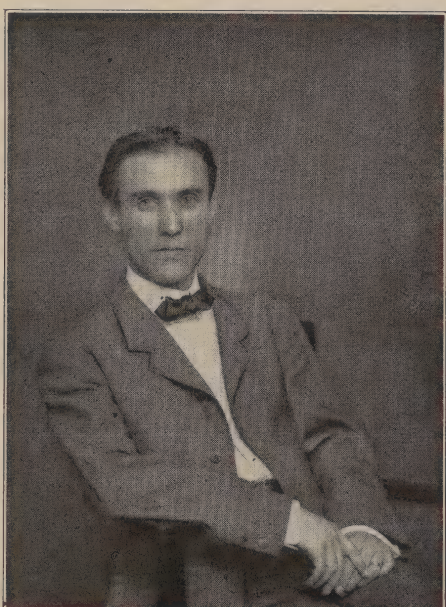
From "The Central Station."

The Central Station should back up the work begun by the periodical by the services of a Department of Illuminating Engineering, in charge of a *competent* specialist. We emphasize the word "competent" advisedly; the work is sufficiently important, if undertaken at all, to be well done, and to do the work well requires not only a certain amount of technical knowledge and skill which have been acquired by study, but a considerable degree of artistic taste and originality, which cannot be acquired by mere study, but must be natural talent. It is safe to say that there is not one installation of lighting out of ten that could not be materially improved by a little study on the part of such a specialist; and it should be his business to unobtrusively study the particular needs of the patrons and give them every assistance possible by way of suggestions and calculations. "A pleased customer is the best advertisement"; there is no doubt about that; and it should be the general aim of the engineer to see that the patrons are pleased with their illumination. It is not sufficient that they simply do not make complaints. Americans are not much given to complaining; it is quicker and less troublesome to simply discard absolutely that which is unsatisfactory. A specialist of the sort mentioned, keeping continuously in touch with the consumers, would render a complaint department useless; or perhaps we should rather say that this department should be put entirely in his charge.

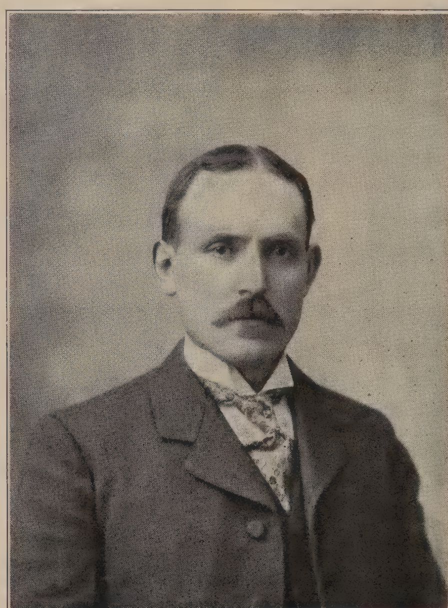
There are innumerable ways in which electric lighting can be made more attractive and economical, from the simplest case of a light in a dwelling house, to the most elaborate system in a public building. The consumer has neither the time, nor the skill, nor the inclination, to study out these matters; in fact, he has a fair right to look to the company which is taking his money, for all possible assistance in this line. We believe that the establishing of such a department in connection with the central station would show a large dividend on the investment, and a quicker return as an advertising expense than could be obtained in any other way.

A. A. POPE,
VICE-PRESIDENT.

C. H. SHARP,
VICE-PRESIDENT.



V. R. LANSINGH,
TREASURER.



E. L. ELLIOTT,
SECRETARY.

The Illuminating Engineering Society

MR. LOUIS B. MARKS, PRESIDENT.

The most significant sign of the times, bearing upon the recognition of illumination as an engineering problem, is the formation of the Illuminating Engineering Society, which was consumated on the 10th of January this city. The following record of the inception and growth of this movement affords ample proof of its popularity. The general readiness, amounting in most cases to actual enthussiasm, on the part of the leading representatives of the various interests concerned with problems of illumination, furnishes proof that this movement falls in an auspicious time, and assures for the Society a rapid growth to such a position of importance as will place it among the old established technical societies of this country.

A general report of the three meetings held, together with the constitution and by-laws, adopted, follows:

The following circular letter was sent out to about thirty people known to be interested in the subject of illumination:

227 FULTON STREET.
NEW YORK, December 13, 1905.

Dear Sir:—

It has been proposed to form a Society of Illuminating Engineers, composed of those people who are especially interested in the question of light and its distribution. For this purpose, the undersigned have asked a number of those most prominently interested in such questions to meet at the Hotel Astor, 44th street and Broadway, this city, on Thursday evening, December 21, at 6:30 o'clock, to talk over the formation of such a society and to discuss whatever is necessary to accomplish this purpose. We trust you will be able to attend this meeting and would ask that you kindly let Mr. L. B. Marks, 202 Broadway, New York City, know beforehand so that arrangements for an informal dinner may be made. The price of this dinner will be $1.00 each.

Trusting that we may have the pleasure of meeting you at that time, we are,

Very truly yours,
L. B. MARKS,
E. LEAVENWORTH ELLIOTT,
VAN RENSSELLAER LANSINGH.

P.S.—The dinner will be purely informal and business suits will be in order.

In response to this call twenty-five of the recipients assembled at the appointed time and place.

The meeting was called to order by Mr. V. R. Lansingh, who nominated Mr. L. B. Marks for temporary chairman. This nomination was variously seconded, and Mr. Marks was unanimously elected.

Mr. E. L. Elliott was nominated for temporary secretary; seconded and carried unanimously.

After a few preliminary remarks by the chairman, the following letters were read:

Department of Physics, Cornell University.
Ithaca, N. Y., Dec. 16, 1905.
Mr. L. B. Marks,
No. 220 Broadway, New York.

Dear Mr. Marks:—Your letter of December 14th, inviting me to meet those interested in the organization of a society of the Illumination Engineers at dinner in New York, on December 21st, was duly received. I am very sorry to be unable to accept, for I am in hearty sympathy with the idea of having such a society. I believe that it will serve to advance our knowledge of a much neglected branch. I have unfortunately promised to do between now and Christmas more than I can hope to accomplish with the use of every day and some of the nights. Kindly express my regrets, and my interest in the cause, to those who gather with you at the Hotel Astor.

Yours very truly,
Edw. L. Nichols.

Purdue University, Lafayette, Indiana.
December, 19, 1905.
Mr. Louis B. Marks, No. 220 Broadway,
New York City.

My dear Marks:—I have your letter inviting me to attend a meeting of engineers interested in illumination, at the Hotel Astor on the 21st inst.

I beg that you will accept my thanks for the invitation, but I have also to send my regrets at being unable to attend on that date. Our work is just closing prior to the holidays and it would not be possible for me to go to New York for the meeting. I desire to express my entire sympathy with the movement and my belief that a new and legitimate field of engineering will be the outcome of the movement and no one can tell at this date to what extent it may grow in the very near future.

Assuring you of my best wishes for the success of your proposed society and my willingness to co-operate with you in any way that may be possible, I beg to remain,

Very sincerely yours,
C. P. Matthews,
Director, Electrical Laboratory.

Treasury Department,
Office of the Secretary.
Washington, December 20, 1905.
Dear Sir:—

I desire to acknowledge the receipt, both on behalf of Mr. J. E. Woodwell and myself, of your valued invitation to be present at a meeting to be held at the Hotel Astor, New York City, on December 21, 1905, with a view to the formation of a Society of Illuminating and Illumination Engineers.

We have delayed replying to this invitation in the hope that we would every day be able to assure you of our personal attendance at the meeting, but now at the last moment find that neither Mr. Woodwell nor myself will be able to attend. I can assure you of our interest in the movement for the organization of such a society and trust that the meeting will be a thorough success.

Very truly yours,
Proctor L. Dougherty.

New York Edison Co., 55 Duane street.
New York, December 19, 1905.
Dear Mr. Marks:—

The letter of December 13th informing me of the proposed formation of a Society of Illuminating Engineers, has just been received. This seems to be a most interesting matter, and I will surely endeavor to attend the meeting suggested. At the present moment I cannot say definitely whether this will be possible, but I trust that I will be able to be on hand.

Assuring you of my hearty approval of the formation of such a society, should I be unable to attend in person,

Yours very truly,
Walter E. Boyd.

Editorial Department, *The Electrical Age.*
New York, December 18, 1905.
Dear Sir:—

Referring to a letter received two or three days ago calling attention to the proposition to form a Society of Illuminating or Illumination Engineers, and the contemplated talking over of the preliminary arrangements at an informal dinner to be held at the Hotel Astor on the evening of December 21st, I would say that it will give me great pleasure to be on hand, or to be represented by one of my associates. The matter is an interesting and an important one, and it would seem to me that such a society would be able to accomplish much good work.

Very faithfully yours,
Albert Spies,
Editor.

Editorial Rooms,
The Electrical World and Engineer.
New York, December 16, 1905.
My dear Mr. Marks:—

I beg to acknowledge receipt of the kind invitation signed by yourself, Mr. Elliott and Mr. Lansingh, to the dinner next

Thursday, and regret very much that a previous engagement will not allow me to attend. Were I, however, to have the pleasure of being present, there are several considerations which I would ask permission to present in relation to the matter that will be under discussion at the dinner, and perhaps you will allow me to set them down here. I shall say, first, that I am in entire sympathy with the movement toward establishing illuminating engineering as a specialty, for I thoroughly believe that in view of the present keen competition of gas, the industry as a whole will be highly benefited by placing the matter of the distribution of light units in the hands of specialists who will produce the best results with the least expenditure of energy. I regret to say, however, that I do not think this end can be best served by the formation of a Society of Illuminating Engineers for two principal reasons which I will outline below:

First, I believe that before illuminating engineering can become fully appreciated and reach the status which it deserves, a great deal of missionary work is necessary, and particularly among the whole body of electrical engineers of this country. I think it must be confessed that at the present time consulting electrical engineers and others laying out lighting circuits consider that they themselves are sufficiently qualified to work out problems relating to illumination, and that until convinced to the contrary they will oppose the participation of an illuminating expert in the laying out work on which they are engaged as engineers, or concerning which they are asked for advice. Then again, the development of illuminating engineering is so recent that the great majority of electrical engineers in general know little or nothing concerning it as a professional branch, and any movement which would cause the prejudice of the first class to become active would undoubtedly result in rallying to this class very many who at present have taken no stand on the question.

Assuming that the above situation does exist, the deduction is that the time is particularly ripe for missionary work with a view of removing prejudice where it does exist, and establishing favorable impressions among the second class above mentioned. With a membership at present of over 3,700, the American Institute of Electrical Engineers may be accepted as almost exclusively representative of the American electrical profession, and it follows that it is highly desirable that this missionary work should be most largely conducted among the members of this body. That is to say, the only audience worth considering at the present juncture, whether this respect to direct the influence or indirect influence through its members, seems to be that of the American Institute of Electrical Engineers.

I therefore think that instead of forming at the present time a separate body, it would be very much wiser if the illuminating engineers of this country were to exert all their efforts towards spreading knowledge of the art of illuminating engineering and the functions of the illuminating engineer, through the Transactions of the American Institute of Electrical Engineers. I believe that illuminating engineers should get together and draw up some plan (without communicating it to outsiders) whereby this purpose could be carried out, rather than organize as a separate national body. For instance, I think there would be no difficulty in arranging for an Institute meeting date at which the subject would be illuminating engineering as represented by a number of papers. I believe also that arrangements could be made whereby at least once a year a paper on illuminating engineering would be read before the Institute at one of the ordinary monthly meetings.

Second, the formation of a body of illuminating engineers, many of the members of which would be present members of the A. I. E. E., would be regarded by perhaps the majority of members of the latter body as an injury to the Institute; or if the feeling would not be this deep, it would at least amount to a prejudice against the new body. I do not make this prediction as one based upon the known feelings of electrical engineers, but rather because the history of professional bodies in Great Britain and this country have shown that the setting up of a body representing even a minor object of an existing national body is always resented, and alienates the sympathy of members of the older body from the members and purposes of the newer one. In view of the apparent feeling, passive though it be at present, of the more prominent installation engineers against illuminating engineers, it seems to me it would be particularly unfortunate to take any action that would enable them to rally others to their standard, though being afforded an opportunity to appeal to professional society prejudice.

To resume, I think it would be very unadvisable at the present time for illuminating engineers to take an action that would deprive them of the ideal channels afforded by the American Institute of Electrical Engineers for creating professional sentiment in their favor, and which would arouse against them the powerful opposition of the A. I. E. E. on the ground that the new society is a schismatic body.

Finally, I will say that if it be decided to organize the proposed body, it can count on our hearty co-operation, and on our aid in allaying any feeling of antagonism aroused by the action.

Sincerely yours,

W. D. Weaver.

The New York Edison Company,
55 Duane Street, New York.
December 21, 1905.

Mr. L. B. Marks,
At Meeting of Illuminating Engineers,
Hotel Astor, New York City.

My dear Mr. Marks:—I beg to offer several suggestions which grew out of our talk of yesterday in reference to the proposed organization of a society or association into which could be gathered the many interests that would co-operate toward investigation and discussion of methods for improving the applications of artificial illumination.

It would appear to me that this subject has arrived at a stage where it could well be specialized, even though the general subject is one which comes within the purview of already existing professional bodies such as the American Institute of Electrical Engineers or the American Gas Light Association. As such an association must necessarily include within its membership electrical engineers, gas engineers, chemists, fixture makers, architects and others, it would seem to me that it would be desirable to limit the membership to one class of members and to eliminate as far as possible all professional qualifications for membership.

I do not believe that such an association on the lines above indicated should undertake at this time to set up a high qualification either from a scientific or technical standpoint, but should undertake to keep its doors as wide as possible so as to embrace all who would co-operate toward the advancement of the art of illumination.

I would emphasize that very great care be taken so as not to conflict even in appearance with the existing technical bodies such as the American Institute of Electrical Engineers or the American Gas Light Association, but it would seem to me desirable to open the doors as widely as possible to commercial interests also as well as the professional class.

As I stated to you yesterday I believe that the success of such an association will depend very largely upon the selection of a proper name, and I have not been able to find a good "American" equivalent for a German title which happened to occur to me at once, for instance "Verein für Beleuchtungswesen." If you could find a satisfactory equivalent which would cover the ground quite well, it would, I believe, go far toward meeting the situation.

Yours very truly,
J. W. Lieb, Jr.

The Chair:—The most important topics that will come up for discussion this evening will be the object of the society, its name, and its relation to its sister institution, the American Institute of Electrical Engineers. It seems to me that it would be wise before closing this evening to appoint a committee to go into these various matters, and meet, say two weeks from now, and then present their recommendations to the members to be voted on. The same committee should be authorized to draft a constitution and by-laws. A discussion of the name and object of the society is now in order.

Question: (By member)—I would like to ask for information, as to whether or not the foreign Engineers' Societies do not have some divisions of engineering specialties in their organizations?

The Chair:—I am not familiar with the general practices abroad; perhaps some of the members might answer that question. My impressions are that they do. The International Electrical Society, of which I am a member, would not come under the head you name. Dr. Sharp has investigated a number of societies over there, and might be able to tell us whether there are any branches, or specialties, that he knows of.

Dr. Sharp:—I am not sufficiently familiar with the conditions in regard to this in foreign scientific societies to be able to answer.

Question: (By member)—Do you suppose it would be feasible to form a society of Electrical Engineers for this special work?

The Chair:—In order to expedite the discussion, I will take the liberty of calling individually on those present for their opinions. We would like to hear from Mr. Wilcox.

Mr. Wilcox:—I prefer to hear the discussion of that particular point rather than express my own opinion; but how are you going to get a combination of the acetylene and gas interests, which are becoming a very important factor in illumination? Most of the people here represent electrical interests, and I don't think that we ought to consider for one moment that the society should be limited to the electrical interests; it should include both gas and electricity. If limited to electricity, you immediately count out your other parties, which is a very serious objection.

Mr. Ryan:—As to the question of a name, I would suggest "Light Improvement As-

sociation," but I think it is something that will have to be handled very carefully. As to the field of the illuminating engineer, this has been very materially changed in the past five years. We now get requests right along from engineers and architects to discuss the lighting of certain buildings.

Dr. Sharp:—I have not given this matter any great amount of thought, but certainly the matter appeals to me very strongly indeed. The American Institute of Electrical Engineers has always given a certain amount of attention to questions of light, illumination, and photometry; but all these matters are far from being properly recognized. I think we should consider rather carefully the question, whether it might not perhaps be better to endeavor to bring this question of illumination to the attention of the Institute, for a while at least. To be sure, that does not include the gas interests, and they are of tremendous importance. I certainly think that before anything is done the thing will have to be put in the hands of a representative committee, who will go into the matter very carefully, and take the thing up with the members of the American Institute, and also with some representatives of the Gas Light Association.

The Chair:—Mr. Kellogg, who is doing great work in illumination, is here; we would like to know what he has to say about the formation of a society of this kind, and whether, in his opinion, the best interests of illumination could be secured by the formation of a society of this kind.

Mr. Kellogg:—Two years ago the architects thought an illuminating engineer was a man who assumed a great deal, but who knew little about the subject. Now they are beginning to realize that there is something in it. I think perhaps a little more missionary work might do some good, but I do not think the subject has as yet so advanced that the architects will appreciate it.

Mr. Page:—I am very much interested in the formation of a body of Electrical Engineers, or rather of Illuminating Engineers, to discuss together this question of illumination. I find in my experience in talking with various illuminating engineers that each one at the present time seems to have his own particular hobby. There are all sorts of problems that have had very little discussion and consideration up to the present time; and as the subject is brought to my attention from time to time, I am surprised, after the years I have spent in the incandescent lamp business, to find how little I know about it. There are a whole lot of problems that have, up to the present time, received very little attention, and if a body of men could meet once a week, or once a month,—call the society what you please,—the time would be well expended. You have got a work that ought to be done, and done right away. A whole lot of time and work will have to be expended to bring about the results you want to accomplish. I believe that almost half of the electrical energy used for light is wasted in the city of New York. There is no branch that I know anything about that seems to me is so badly done as illuminating engineering. Look up history and you will find that we are following precedents that were established thousands of years ago; it is hard to get away from them. I do not care what you call yourselves; but if you can get the men that are particularly interested together and get them to discuss the various matters,—let Mr. Ryan bring out the results of his experience; let Mr. Mygatt present his methods, and tell what he can do; each has its own particular best sphere; they will then be able to place it before the public so that an engineer can take the work here and can understand so that he can go to work with some data with some line of books or pamphlets to go on as a standard.

Mr. Olcott:—I do not see that I have very much to add, except that the name should be a proper one. I would suggest leaving out the word Engineer, and call it the Illuminating Society, or Illumination Society.

Mr. Mygatt:—In what way do you consider the fixture manufacturer would be benefited by the formation?

Mr. Olcott:—The fixture manufacturer would probably succeed in making a fixture without so many kicks about insufficient light, etc.,—due generally to the fault of the current furnished by the Edison Company. (Laughter.) The chief thing would be to bring us together.

Mr. Pope:—I do not know that I can

add very much to what has already been outlined; but I will say this for the benefit of our fixture manufacturers, that it is a very frequent occurrence that we are called upon to explain why one customer's bili is much higher than the other, and very often find that the fixture manufacturer is the cause. We do the best we can with what is left to arrange the lighting, perhaps not as an engineer would do it, but as one who is trying to meet the conditions of illumination. I believe that there is a great field, and a field that is neglected. You cannot walk down a single street of New York without having all kinds of glaring defects of illumination staring you in the face. A half of the energy is wasted; it is true; that is where most of our trouble comes. We are not anxious to waste energy. No business arrangement will remain permanent that is not satisfactory. With a man who has not had his place scientifically illuminated it is very hard to overcome these conditions. We do the best we can with what is left. I do believe that something should be done in that line. I feel as Dr. Sharp has said, that a committee should be appointed to consider the subject from every point of view.

Mr. Howell:—The subject of wasted light interests me very greatly. It has been a hobby of mine, ever since Mr. Page and I put up a great big sign down on 23rd street, to cut down the size, and increase the number of lamps, in signs especially. I do not believe you will find anywhere in this city a greater waste of light than in the electric signs we have. If they were to use 2 or 3 candle-power lamps instead of 8 and 10, they would get far better results. Go along Riverside Drive and try to read the large electric signs across the river on the Jersey shore; you will find that they are blurred so much that you cannot pick out the letters at all. I feel strongly on the subject of bringing in the gas engineer, and the representatives of all other sources of artificial illumination. I think it would be a mistake to tie up to one subject alone.

Major Zalinski:—I came here to get the opinion of the members on the subject. I fully agree with Mr. Page that there is a great waste of current in the prevailing methods, and that good results can be obtained with a less expenditure of current.

Mr. Mygatt:—I do not think that the word "engineer" would be particularly objectionable. Why should the words Illuminating Engineer be objectionable in any way? It certainly applies as much to gas as it does to electricity.

Mr. Elliott:—It seems to me that to omit the name "Illuminating Engineer" would be, in a measure, to defeat the purpose of the association. It seems to me that illumination and the use of light, whether it be artificial or daylight, has become a sufficiently diversified branch of knowledge to require all the time that one can give to its study if he is to master the subject, or to even approximately perfect himself. If that is the case, he has as good right to call himself an "engineer" as the man who gives his time to heating and ventilation, or sanitation, or refrigeration, and calls himself an "engineer" in any of these special fields. I was somewhat surprised to find that there might be a feeling on the part of the American Institute of Electrical Engineers in regard to the formation of such a society under such a name. I cannot comprehend why they seem to claim exclusive rights to the title of Engineer. There is something in a name, especially in the opinion of the public. I should feel very sorry to see the name "engineer" left out of the title.

Mr. Miller:—I think that the question of illumination has been wofully neglected. Societies such as the American Institute and the gas associations have neglected it because it has been subordinated to greater interests,—interests which demanded immediate attention. Light will take care of itself in some sort of a way, and is naturally neglected. I do not believe that it is possible that electrical and gas organizations will give to the question the attention and consideration which it deserves, and feel quite sure that it is only by the organization of a society of this kind that our object will be attained. The question of light wasted appeals to me very strongly. I think Mr. Page is correct in his statement that half of the current that is generated is wasted, and is certainly large enough to command the attention of a society organized for the specific purpose.

Major Zalinski:—Why would it not be

well to use such a name as "The Society for Economical Illumination, or Light," the word Engineer to come afterwards?

The Chair:—I think it would be well to leave that to a committee. You might understand the term, but the architect might look at it from a different point of view.

Mr. Ryan:—Five years ago it was almost impossible for a consulting illuminating engineer to get into an architect's office. Three years ago the work had increased to such an extent that I was obliged to drop all other work and follow illuminating engineering exclusively. I have now six assistant engineers and every one of us is on the go. In the spring the General Electric Company are going to put up a great laboratory at Lynn, so that at any time an architect or engineer would like to see a certain effect that effect can be reproduced so as to form a basis for drawing up the final specifications. In conjunction with that we will have all kinds of measuring apparatus, etc., to make it as practical as possible; so that the company feel that it is of sufficient importance to expend a large amount of money with the idea of applying the proper thing to the proper place.

The Chair:—I would ask you to consider the appointment this evening of a committee to take up this question of the name of the society, and to draw up a constitution and by-laws, to be submitted to the members who may attend the next meeting; those who attend the next meeting, or signify their intention of doing so, to be called the charter members.

Mr. Elliott:—I move that a committee on organization, consisting of five members, be appointed, to report in two weeks from this evening, at a place to be appointed, a constitution and by-laws, and such other regulations as may be necessary for establishing an association which shall be devoted to the interests of furthering good illumination.

Mr. Ryan:—I second the motion.

Mr. Howell:—I move that the committee consist of seven members.

Mr. Elliott:—I accept the amendment.

The Chair:—If there are no objections, the committee will consist of seven members.

Moved and seconded that the chairman be the nominating committee.

Motion prevailed.

The Chair:—I want to announce that the New York Edison Company has offered us the use of their assembly hall for a meeting place. The hall is No. 44 West 27th street, and has been well fitted up for this purpose. I would suggest that we hold the next meeting on January 2nd, in the assembly room of the New York Edison Co., unless the committee shall advise some other place. The Secretary will send notices of this meeting in advance, and I would like to know whether all of you expect to be present at that meeting.

Member:—I would like to know whether it would be practical for the Committee to report what they think best to do before the next meeting, so that the other members will have a chance to consider the matter. If members think that more time should be given to the subject, it seems to me that it would not be wise to act at that meeting; on the other hand, if the members think that the matter has been boiled down, we could act on it.

Mr. Lansingh:—Why would it not be well for the committee to act as early as possible, get up a circular letter and let the members think it over; then we would be much better prepared to consider the question than we would otherwise.

A motion to this effect was made and seconded.

The Chair:—It has been moved and seconded that a circular letter containing the results of the deliberations of the committee be sent to the prospective members of the society in advance of the date of the next meeting.

Motion prevailed.

Mr. Page:—It is the desire of those present that as many people be brought to the next meeting as can be found who are interested in the formation of this society. Undoubtedly all of us know a great many men who would be very much interested and who would be glad to attend.

Mr. Elliott:—I am also of the opinion that it would be very well indeed if every one present here this evening would send in a list to the Secretary, as soon as they can conveniently do so, of those they would like to have attend the next meeting. If they would send in the names of such, the

Secretary could then send them the report of the Committee on Organization, and they could be posted as to the object of the meeting.

Mr. Page:—I might mention a number of men that have no time to devote to illuminating engineering, but who are very much interested in it. As to whether you want a class of men who undoubtedly will never make a business, or profession, of illumination, I should say most decidedly, Yes. Mr. Williams told me this evening that he knew fifteen or twenty such men. I met a mechanical engineer this morning who expressed a great interest in the subject and stated that he would like to come to the meeting and hear the discussion, etc. You would have no trouble in finding plenty of men who are interested.

Mr. Lansingh:—I make the motion that everybody send a list of those people they want invited to the Secretary, and he send a letter to them asking them to be present at the next meeting.

Motion seconded and prevailed.

A committee of seven was appointed by the Chair, consisting of the following: V. R. Lansingh, Wilson S. Howell, E. L. Elliott, W. D. Weaver, E. C. Brown, W. S. Kellogg, L. B. Marks, chairman, *ex officio*.

There being no further business to come before the meeting, it adjourned subject to the call of the Committee on Organization.

THE MEETING OF JANUARY 10th

Pursuant to a call of the Committee on Organization a meeting to complete the formation of a society devoted to the Science and Art of Illumination assembled at the Hotel Astor on Wednesday evening, January 10th.

The meeting was called to order by the Chairman.

The Secretary gave a verbal report of the proceedings of the last meeting.

The Committee on Organization then reported the following Constitution and By-laws, which were taken up sereatim for discussion.

Motion made and seconded that the Constitution and By-laws be adopted as read. Carried.

Motion made and seconded that those who signify their intention of becoming members on or before the next regular meeting shall become charter members of the society. Carried.

The Chair then announced that election of officers as provided by the Constitution was in order.

Mr. L. B. Marks was nominated for President. There being no other nominations, he was declared elected.

The following names were put in nomination for the office of Vice President: J. R. Cravath, E. L. Elliott, W. S. Kellogg, C. H. Sharp, and A. A. Pope.

Motion made and seconded that the Society proceed to elect by ballot. Carried.

Messrs, Codman and Kellogg were appointed Tellers, who announced that A. A. Pope and C. H. Sharp had received respectively the highest number of votes, and they were declared elected Vice Presidents.

Mr. E. L. Elliott was nominated for Secretary. There being no other nominations, he was declared elected.

Mr. V. R. Lansingh was nominated for Treasurer. There being no other nominations, he was declared elected.

The following were put in nomination for the office of Manager: W. D'A. Ryan, W. S. Kellogg, Dr. A. H. Elliott, C. H. Codman, J. R. Cravath, W. D. Weaver, J. E. Woodwell, J. Livingstone, H. C. Cushing, F. N. Olcott, and E. C. Brown.

Motion made and seconded that the Society proceed to elect by ballot. Carried.

The Tellers announced that the following had received the largest number of votes, and they were declared elected: W. D. Weaver, A. H. Elliott, W. S. Kellogg, E. C. Brown, F. N. Olcott, and W. D'A. Ryan.

Motion made and seconded that the thanks of the Society be extended to the Hotel Astor for its courtesy in furnishing a meeting room for the use of the Society for the two meetings already held, and its kind offer of similar accommodations for future meetings. Unanimously carried.

There being no further business to come before the meeting, adjournment was taken to Tuesday evening, February 13th, at the Hotel Astor.

CONSTITUTION

ARTICLE I.

This organization shall be known as the Illuminating Engineering Society.

ARTICLE II.

The object of this society shall be the advancement and dissemination of theoretical and practical knowledge of the Science and Art of Illumination.

ARTICLE III.

SEC. 1. Any person interested in the objects of the society shall be eligible to membership.

SEC. 2. Any such person may become a member (1st) by making application to, and receiving a majority vote of the council; (2d) by paying the dues provided for in the by-laws.

ARTICLE IV.

SEC. 1. The officers of this society shall consist of President, two Vice-Presidents, Secretary, Treasurer, and six Managers.

SEC. 2. The President shall be elected for a term of one year, and shall not be eligible for immediate re-election to the same office. The Secretary and the Treasurer shall be elected for a term of one year. Vice-Presidents shall be elected for a term of two years, except that at the first election of the Society the term of one vice-president shall be one year, the selection to be by lot. Managers shall be elected for a term of three years, except that at the first election of the Society the term of two Managers shall be one year, and of two Managers two years, the selection to be by lot.

ARTICLE V.

SEC. 1. The general affairs of the Society shall be administered by a Council consisting of the officers of the Society.

SEC. 2. The Council may delegate such powers as they see fit to an Executive Committee, consisting of the President, Secretary and Treasurer of the Society, and two Managers selected by the Council.

SEC. 3. Five members shall constitute a quorum of the Council, and three members shall constitute a quorum of the Executive Committee.

ARTICLE VI.

SEC. 1. The President shall preside at all meetings of the Society, and perform the duties usually devolving upon such an officer.

SEC. 2. In the absence of the President from any meeting of the Society, a Vice-President shall preside, and exercise temporarily the duties of the President.

SEC. 3. The Secretary shall keep a record of the minutes and proceedings of all meetings of the Society, carry on the general correspondence of the Society under the direction of the Council, and perform such other duties as usually devolve upon such an officer.

SEC. 4. The Treasurer shall receive all moneys belonging to the Society, disburse the same at the direction of the Council, and present a full statement of accounts at each annual meeting.

ARTICLE VII.

The Secretary shall, at least 60 days previous to the annual meeting, send

to each member a blank form giving a list of officers that are to be elected; and each member shall be entitled to make a nomination for each office upon such blank, which is to be returned to the Secretary. These nominations shall be canvassed by the Council 30 days prior to the annual meeting, and the persons receiving the largest number of nominating votes respectively for each office shall be declared to be Members' Nominees. The Council shall also put in nomination a candidate for each office, chosen as it may see fit. Tickets giving both lists of nominees shall then be sent to each member three weeks prior to the election, with instructions to vote for one nominee for each office. The nominee receiving the majority of votes shall be declared elected. The election shall take place at the annual meeting. Votes may be either in person at the meeting, by authorized proxy, or by a written ballot duly signed by the member and mailed to the Secretary before the annual meeting.

ARTICLE VIII.

SEC. 1. In case of a vacancy in the office of President, the senior Vice-President shall assume the Presidency for the remainder of the term.

SEC. 2. Vacancies occurring in an office other than the Presidency shall be filled by the Council, a majority vote of the Council being necessary to elect.

ARTICLE IX.

The annual meeting shall occur on the second Wednesday of January, unless otherwise ordered by the Council.

ARTICLE X.

This Constitution can be amended only in the following manner: The proposed amendment must receive the approval of the majority of the Council, and a copy of such amendment so approved be mailed to each member of the Society at least thirty days before the annual meeting, and receive a majority vote of the total number of votes cast for or against at such annual meeting.

BY-LAWS

ARTICLE I.

SEC. 1. Regular meetings of the Society shall be held monthly, except during July, August and September, at a time and place to be decided by the Council.

SEC. 2. Special meetings may be called by the Council, or on the written request of ten members of the Society. Notice of such meetings shall be sent out by the Secretary to all members at least fifteen days prior to the meeting, stating the time, place, and special object of such meeting.

ARTICLE II.

SEC. 1. The annual dues, which shall include the initiation fee for the first year, shall be five dollars, payable in advance.

SEC. 2. Any member in arrears six months for dues shall be informed by the Secretary that he is delinquent and can have no vote or voice in the affairs of the Society until the dues are paid. At the expiration of six months thereafter if still in arrears, he shall be informed that membership will be forfeited if the dues are not paid within

two weeks. If the member continues delinquent the Council may drop him from membership.

ARTICLE III.

A Committee on Papers and Communications, consisting of five members, shall be appointed by the Council. It shall be the duty of this committee to examine all papers and communications that may be received for presentation to the Society, and return them to the Executive Committee with its recommendations. The committee shall have power to exclude or revise any paper before it is presented; provided, however, that in case the paper is revised a copy of the revision shall be submitted to the author in order that the author may decide whether or not he wishes to present the paper as revised. All papers presented to the Society at a regular meeting shall become the property of the Society, which shall have the right to publish the same in any manner the Council may direct.

ARTICLE IV.

Any member may be suspended or expelled from the Society for any cause deemed sufficient by seven members of the Council; but such charges must first be carefully and impartially investigated by the Council, who shall give reasonable opportunity for the accused to put in a defense, and the Council shall then take such action as it deems proper.

ARTICLE V.

The order of business at regular meetings shall be as follows:

(1st) Reading of the records of the previous meeting, and action thereon.

(2d) Report of Council.

(3d) Report of Committees.

(4th) Reception of Communications.

(5th) Unfinished business.

(6th) New business.

(7th) Presentation of papers or addresses.

(8th) General discussion of papers.

(9th) Adjournment.

ARTICLE VI.

These By-laws may be amended at any meeting of the Society providing such amendment shall have been presented at the two preceding regular meetings, and shall receive a majority vote of the members present at such meeting.

ARTICLE VII.

The deliberations of the Society shall be governed by the provisions of Cushing's Manual, excepting in so far as they are provided for by the Constitution and By-laws.

REGULAR MEETING, HOTEL ASTOR, TUESDAY EVENING, FEBRUARY 13th

Meeting called to order by the President.

Motion made and seconded that the reading of the minutes of the last meeting be omitted. Carried.

The President, as Chairman of the Council, reported that the services of Mr. Geo. H. Guy had been secured to act as Corresponding Secretary for a period of six months.

Dr. C. H. Sharp reported that the Committee on Papers had secured papers on the following subjects for the next meeting:

The Luminous Arc Lamp, by E. L. Elliott.

The Inverted Gas Burner, by Victor Rettich.

Illuminating Engineering from the Architect's Standpoint, by W. S. Kellogg.

Mr. Codman asked for information in regard to the policy of the Society as to branches in other cities. On motion duly made and carried the matter was referred to the Council to report at the next meeting.

The President then read an inaugural address which was followed by a discussion as hereinafter reported.

My first word to the members of the Illuminating Engineering Society is one of thanks. I am deeply appreciative of the honor you have conferred on me in electing me to the office of President during this, the first year of the Society's existence, and shall earnestly endeavor to do my full share in the work that we have set out to accomplish.

The movement to bring about the formation of this Society was started only a few months ago. The proceedings of the preliminary meeting which was held on December 21, 1905, and of the meeting of organization which took place January 10, 1906, will soon be published. I need, therefore, not enter into the details of the discussion that was held at these meetings further than to say that the opinion of those who attended was practically unanimous that the time was ripe for the formation of a separate society devoted to the advancement of the science and art of illumination. The interest taken in the cause from the start has been most keen and the fact that in the course of a month over 150 members have been enrolled and that applications for membership are coming in daily unsolicited from various parts of the country, is evidence that there is an urgent demand, I might even say a thirst for the information which it is believed this Society will be the means of disseminating. The present membership is distributed among gas and electrical engineers, architects, fixture designers, and various interests connected with the production of lighting auxiliaries.

PRESENT STATE OF THE SCIENCE AND ART OF ILLUMINATION.

Applying the term illumination to the *use,* in contra-distinction to the *production* of light, it may be truly said that while great strides have been made in recent years in the development of almost every detail concerned with the production of light, illumination, particularly from an economical standpoint has been sadly neglected.

Broadly speaking, the electrical engineer has concerned himself with improving the efficiency of the generating apparatus and cutting down losses in the transmission of power, but when his wires reach the point at which the electric current is to be transformed into light, his engineering skill has not as a rule been applied. Similarly the gas engineer has been busy with questions involved in the manufacture and distribution of gas while the problem of obtaining the maximum value or most effective use of the illumination delivered at the burners has been relegated to a secondary position.

So far as interior illumination is concerned the lighting layout has been left largely to the architect. It is he who usually prescribes the number and location of outlets for the light sources, specifies the number and candle-power of the lamps and designs or selects the lighting fixtures and accessories. Very often these specifications are completed before the color scheme of the interior has been decided upon, with the result that the degree of illumination obtained may fall far short of what is needed in cases of dark-colored interiors or be excessive in the case of light tinted rooms.

The natural tendency of the architect is to make the economical side of illumination subservient to the æsthetic, while on the other hand the tendency of the engineer is to consider only the question of economy. It is an encouraging sign of the times that the architect and the engineer are gradually drawing closer together in dealing with problems involving both the scientific and the artistic side of illumination.

Though much attention has recently been given to the subject of globes, shades and reflectors, the fact still remains that unshaded or inadequately shaded lamps are the rule rather than the exception. In considering the present status of the science and art of illumination there is perhaps no question that is in need of more immediate attention than this one. The practice of placing lights of excessive intrinsic brightness within the ordinary field of vision is so common as to cause great apprehension among those who have studied the question from a physiological point of view that our eyesight is suffering permanent injury. That the percentage of children with defective eyesight is growing year by year, is a well-known fact. According to oculists the strain on the eye caused by bright lights is in a large measure responsible for this condition. Those who have been subjected to the painful glare of the bare lamps used for illuminating our electric cars will attest to the visual discomfort caused by the subjection of the eye to an unshielded source of light even as small as a 16-cp. lamp.

Much of the trouble due to this cause would be removed if the light sources were concealed and the illuminating power from them derived from reflected rather than from direct rays. Happily the tendency of modern illumination is in this direction.

From an economical standpoint the correct disposition of the light sources and the use of the most suitable reflectors are of commanding importance. It is not uncommon to find instances in which adequate consideration of these two questions would result in largely increasing and often more than doubling the useful illumination.

Both electric and gas supply companies are alert to this situation and are now giving these questions more serious consideration than ever before. The far-sighted manager of the supply company sees that it is to his ultimate advantage to assist the consumer in obtaining the very best illumination of his premises at the least expenditure of money for electricity or gas. In view of the above it is extremely desirable that complete and authoritative data be obtained as to the amount and character of illumination best suited for individual conditions. At the present time there is a lack of really valuable up-to-date information on this subject, at least so far as published records go; moreover much of the information that is available is widely scattered and often inaccessible.

The performance of lamps for street lighting and illumination of large open spaces has not been adequately recorded in papers bearing on this phase of the science of illumination. In view of the lack of complete data on this subject there is a wide difference of opinion to-day as to which of several illuminants is best suited for certain cases of street and country road lighting, illumination and economy being considered.

The progress of invention in lamps and lighting apparatus has been so rapid that engineers have found it difficult to keep abreast of the times in the question of illumination. Only a comparatively few years ago the carbon filament incandescent electric lamp, the arc lamp (open or enclosed) and the ordinary gas flame were the only illuminants with which we had to deal. To-day we have besides these among electric lamps, the incandescent lamp of the Nernst type; the mercury arc of the Cooper Hewitt type, the vacuum tube lamp of the Moore type, the impregnated carbon or "flame" arcs, the magnetite arc, and others; and among the gas and oil lamps, the mantle burner lamps of the Welsbach and other types, the oil lamps with forced air draught, the acetylene flame, and several others. The amount of light and especially of electric light used in the United States has grown by leaps and bounds. The consumption of gas for illuminating purposes has also largely increased, the introduction of the mantle burner having given a great stimulus to the gas lighting industry. The place of the acetylene light has been firmly established and the extended introduction

of acetylene plants in the past few years is worthy of special note. The approximate amount of money that is spent by the consumer annually in the United States for illumination by electric light, gas and oil is as follows:

APPROXIMATE COST OF ILLUMINATION TO THE CONSUMER PER ANNUM IN THE UNITED STATES.* (1905.)

Electric light	Between	$100,000,000	and	$120,000,000
Coal and water gas	"	35,000,000	"	40,000,000
Natural gas	"	1,700,000	"	
Acetylene	"	2,500,000	"	3,000,000
Oil	"	60,000,000	"	

At a conservative estimate the consumer is spending a total over $200,000,000 a year for lighting in the United States. Of this amount I venture to say that fully $20,000,000 are wasted—absolutely wasted, so far as the amount of useful illumination delivered for the the money is concerned. No one who has made a study of the subject can fail to see glaring examples of this waste at every hand. It is not at all uncommon to find in electric lighting that 25 per cent. of the light that is furnished is lost so far as any useful purpose is concerned, by reason of improper disposition of the light sources or unsuitable equipment of lamps, globes, shades or reflectors. In gas lighting though the conditions are quite different, the same criticism in a measure holds true.

AIMS AND OBJECTS OF THE SOCIETY.

It is one of the aims of this Society to assist in remedying the conditions just referred to, to point out in what way the best illuminating result may be obtained from any source of light, be it electric, gas, oil, or candle. With this object in view the theoretical and the practical side of lighting will be given full consideration and the æsthetics of the question studied alongside of the economics. The Society will aim to gather into its fold the various interests that are identified with the development of the science and art of illumination in all its phases. The specialist in illumination, the electrical engineer, the gas engineer, the architect, the designer of electric and gas fixtures, globes and reflectors, and the decorator will meet on common ground to discuss the question of illumination from all standpoints. The views not only of the engineer but for the practitioner will be courted. The keynote of the organization will be co-operation in all that makes for the good of the cause.

* In the U. S. Census Report on Central Electric Light and Power Stations issued 1905, T. C. Martin gives the following data: Income derived from central stations in United States for year 1902 for sale of current for electric lighting, $70,138,147, of which $25,481,045 are for arc lighting and $44,657,102 for incandescent lighting. The number of arc lamps reported is 419,561. The number of incandescent lamps, 18,194,044. In addition to the above I estimate that there are about 300,000 arc lamps in use in isolated plants. On the basis of 3½ hours per day, or 1,100 hours per year average use per arc at an average cost of 3 cents per lamp-hour, the cost of lighting per annum by arcs in isolated plants would amount to $24,000,000.

Of the 45,000,000 or more incandescent lamps sold in the United States in 1905 it is estimated that about 70 per cent, or 31,500,000, were 16-cp. lamps; about 7 per cent., or 3,150,000 more than 16 candlepower and the balance less than 16 candlepower. On the basis of the data submitted in the Census Report above referred to, I compute that there were in service last year in isolated plants about the equivalent of 20,000,000 16-cp lamps. At 1 1/3 hours a day, or about 400 hours per year average use per lamp, at an average cost of 3/10 of cent per lamp hour, the cost of lighting per annum by incandescent lamps in isolated plants would amount to $24,000,000.

According to the Census Bulletin on Manufactures issued January 3, 1902, the value of coal and water gas manufactured in the United States in the year 1900 was $69,432,582. The proportion of fuel gas to illuminating gas is not stated in the Report, but is estimated at about 50 per cent. In the Census Report on natural gas, the value of natural gas produced during the year 1902 in the United States is given at $30,867,863. Only a very small percentage of the total consumption was used for lighting purposes. According to H. L. Doherty the value of natural gas used for illuminating purposes during the year 1905 did not exceed $1,700,000. The figures for acetylene gas were estimated from data received from the Union Carbide Co. The figure for oil was obtained from the statistical department of the Standard Oil Co.

The Society will undertake to gather authoritative data on the subject of illumination and render it readily accessible to those interested. It will hold monthly meetings during the year 1906, except in the months of July, August and September. At these meetings papers dealing with all sides of the question of lighting will be read and discussed. These papers and the discussions thereon, together with reports of special committees and data collected, will be published in the Transactions of the Society and distributed among the members.

SCOPE OF THE SOCIETY.

The term "engineering," as used in the name of this Society, unless viewed in its broad sense, is to a certain extent a misnomer, as the Society will deal with some phases of illumination that may not properly be said to come within the distinct field of engineering, such for instance as the physiological side of the question. The Society will be interested in every phase of the subject of illumination whether from an engineering point of view or otherwise, and will throw its doors quite as wide open to the layman as to the professional. It will not, however, deal with questions relating to the production or distribution of the energy from which the light is produced.

The question of candle-power rating and of nomenclature will receive the attention of the Society. At the present time it must be confessed that the rating of lamps often leads to a great deal of confusion. Some lamps are rated on the basis of horizontal candle-power; some according to the downward candle-power and some according to other standards. The Society will endeavor to assist in bringing about a uniformity of candle-power ratings and the general acceptance of certain nomenclature.

From what has preceded it will be seen that the scope of the work to be performed by the Society is broad. The Committee on Papers has suggested a number of subjects on which papers will be written for presentation before the Society. Among these are "Principles of Interior Illumination with Special Reference to Cost, Color of Light and Physiological Effects"; "Street Lighting," "Illumination Data," "Lighting with Special Reference to Ventilation," "Lighting with Special Reference to Distribution," "Illumination from the Architect's Standpoint," "Aesthetics vs. Utilitarianism in the Design of Fixtures, Globes, Shades and Reflectors," "The 'Flame' Arc," "The Inverted Gas Mantle Burner," "Vacuum Tube Lighting," "Oil Burners," "Acetylene Lamps," "New Illuminants," "Candle Power Rating of Illuminants."

One feature of the work of the Society will be the consideration of special cases of lighting as, for instance, the proper illumination of the assembly hall or auditorium, of the library, of the drawing room, of the factory, of the store, of the show window. The degree of illumination best suited to the individual conditions will form the basis of an investigation to be made at the instance of the Society. Besides the subjects mentioned above there are many others which need not be enumerated here that come within the scope of the Society.

RELATION OF THE SOCIETY TO OTHER ORGANIZATIONS.

While the general subject of illuminating engineering comes within the purview of several other organizations, such as the American Institute of Electrical Engineers, the American Gas Light Association and the National Electric Light Association, the special field of work that has been mapped out for the Illuminating Engineering Society, as has already been stated, the electrical engineer, the gas engineer, the architect, the fixture maker and the decorator will meet on common ground. The work of each of these interests in the Society will be concentrated on the subject of illumination. By such specialization the advancement of the art can best be furthered. Illumination is but a very small part of the field that must be covered by the American Institute of Electrical Engineers. The American Gas Light Association and the National Electric Light Association are both concerned largely with questions of generation and distribution, rather than utilization of the light produced. These latter societies meet only once a year. To adequately cover the ground and keep abreast of the times a society devoted to the advancement of the science and art of illumination must meet frequently.

The Illuminating Engineering Society is in no sense antagonistic to other organizations that have to do with lighting. On the contrary, the Society aims to co-operate with such organizations to secure the best interests of all concerned.

DISCUSSION.

Dr. C. H. Sharp, of the Electrical Testing Laboratories:

Mr. President and Gentlemen:—The President's address has indicated to us some of the lines of important work with which a society of this character can deal. There is no doubt about the great importance of these things. The President has pointed out the monetary value of the material which is used in this country for the production of light. It is very great, and it is very important that the final product, which is the light, or more specifically, the illumination, should be used to the best advantage. The electrical engineers and the gas engineers have been actively engaged for years in an endeavor to carry the economic refinements in the production of electricity and gas to the farthest point. In a remarkable paper which many of us listened to a few nights ago at the meeting of the American Institute of Electrical Engineers, Mr. Stott pointed out the possible improvements in economy which were in sight in the production of electric current, and I think that the striking thought of Mr. Stott's conclusion was the small percentage of gain which could be expected by the introduction of refinements in the production of electricity along the lines which are at present being pursued; that is to say, with the use of large steam-driven units. The gain which could be expected by the use of better boiler economies and the use of high superheat is a small one, but by making radical changes in the prime mover used in the production of electric current, larger gains can be made. But we have right at hand means by which more considerable gains in the results achieved can be attained by the manipulation of the light which is produced by this current. The electrical engineer goes to great lengths to gain a small percentage in the economy of his boiler, engines, generators and transmitting system; the illuminating engineer has a problem which in many ways is far easier, because he can take the bad conditions which prevail at the present time and can produce a much more considerable betterment in results than lies within the easy reach of the electrical engineer. So many instances of bad management in the utilization of light are presented to us that it need hardly be more than pointed out, that it is possible to gain more considerable economies, and these economies are quite as useful as the additional economies which are to be attained in the generating plant.

It is to these matters that this society is to give its attention, and there is no doubt that the work is of very great importance and that it has been very sadly neglected in the past. In speaking further of the economical side of the question, we must remember that we are by no means at the ultimate point in the economy in the production of light. The newer illuminants which are now being presented to us, or which are promised to us, in themselves will result in economies which are greater than can reasonably be hoped for in the generating plant. The change, for instance, which is perhaps in sight, from a standard incandescent lamp using 3.10 watts per candle to a lamp using 2.5 watts per candle, represents an enormous percentage of gain in the economy of the production of light; and it is to such matters as these that the Illuminating Engineering Society can give its attention.

As the President has pointed out, a good many classes of workers are and should be represented in this society. Some of us are interested in the questions of the best handling of light-sources to produce the results which are desired. Others are interested in the accessories, in the manufacture and sale of accessories which will aid in the production of better illumination, or of more artistic effects; others are concerned with the fixtures by which the lamps are supported and which are very important in producing the result. The architects who have membership here have also a wide field for their consideration in the question of the distribution of illumination and illuminants so as to produce the best effect in accordance with their ideas. Some of us are interested in the more abstruse questions of the measurement of light, and of

the proper rating of the sources of light, a rating which shall be rational and which will indicate at once something about what the source of light will actually perform. We are interested in the subject of nomenclature of the system of units to be adopted, and the name to be given them. For instance, we find that in the decimal system as it is used in Europe, a very good system of units has been worked out for the measurement of intensity of the source of light, intensity of illumination, total flux of light, total quantity of light produced, etc. Names have been given to these units and the matter has been put on a thoroughly satisfactory basis. In this country we cannot say that we have attained that point, and there is a field for very great usefulness on the part of this society in securing the adoption of a rational system of units and suitable names for them. We find illumination measured in this country in "candle-feet," "feet-candles," "candles-foot," and several other things. The situation is not a good one. We ought to have a unit of illumination and we ought to have a name for it, and it ought not to be a name which has three or four different plurals. There ought to be a name which indicates one thing and which is convenient and easy to use, and which gives in itself an idea of what we are talking about.

I think it is a matter of congratulation that this society has numbered in its membership so many representative men of all the interests involved, and I think it is a matter of particular congratulation that we can attract the attention and elicit the co-operation and support of men of the type of Prof. Nichols, who has probably done more in the way of the scientific study of sources of light and in the way of blazing a trail into the unknown which is beyond us, in the way of the production of more efficient sources of light, than any other man, and we should be very glad indeed that we can get such men as members. I hope that this society will prove of very great usefulness to all concerned.

Dr. Arthur H. Elliott, of the Consolidated Gas Company, New York:

Mr. Chairman and Gentlemen:—In thinking over your President's address, which covers so wide a range, the first thing that strikes me is the need of workers. We are organized for a purpose, but a little bunch of a half dozen cannot do all the work. Each man should consider himself a committee of one to do his share, either by presenting a paper at the meetings, or taking part in the discussion. As a gas man, I would call the attention of the President to some of his figures with regard to gas. I am not willing to admit that the gas man has only \$35,000,000 or \$40,000,000 interest in this lighting business. Now, I may be a little touchy on this question, but I think we are pretty nearly up to the electric light man when you talk about money matters. We may not light so many streets, we may not have so many lamps on Broadway, but when you take into consideration the large cities which are still very generally lighted with gas, I think your figures, Mr. President, are somewhat small; but it simply shows to what a large extent, to what important money values this lighting question goes.

I heard a gentleman say one evening here, at one of the early meetings, that he believed about half the energy they were putting out on Broadway was wasted; I mean the electrical energy. I am not prepared to admit that the gas men are losing as much as that, but I will say they are losing a very large proportion. I think as a rule that the average householder is getting about two-thirds of the light value out of his gas that he ought to, and I do not think I am exaggerating it one bit; in other words, there is a field for education here among men who are interested in this light question that is just as important in the line of gas as it is in the line of electricity. It is extremely important to induce people to put in good burners, to have the burners properly distributed in the house, and not only that, but to take reasonable care of them. One of our good members to-night said he thought that was a hopeless task, but I think these things are not entirely hopeless. I can remember the early time when it was said that it would be a hopeless task to teach anybody to cook with gas. Our good friend, Mr. Clark, who is here, will tell you it is not any longer a hopeless task to keep his staff busy in selling heating and cooking appliances, so that you must not be discouraged with the idea that it is hard to make people with

average intelligence understand these questions; it can be accomplished by constant hammering, and this little band of workers here can readily do it.

There were one or two other interesting questions touched upon by our worthy President, and one was the physiological question. That is more important than you think. I remember in the early days when the Edison and the Brush Companies were flooding our streets with lights, that they were away up on big poles, and you had to turn your heads up in the air to see the lights. When the Edison and Brush Companies started, the New York gas companies' stock ran away down. Some one told me it was worth $50, par value $100. The Edison and Brush stock was $500 or $1,000. Everybody got scared—that is, those in the gas business; but mark what happened. These gentlemen flooded our streets with light. The people went around New York at night and saw these bright lights, and on going home they began to growl at the gas companies for giving such poor light, and they lit more burners. What was the result? In two years, instead of losing ground, we gained 18 per cent. on our output, not from anything we had done, but from the physiological effect of these bright lights on the eyes. The people sought more light in their homes. You can hardly satisfy them now in their demand for light. Look at Broadway, between 34th street and this hotel—there is no street in the world which has so much light on it at night. That affects your eyes; you go home and are not any longer satisfied with the gas we give. You want us to give you better gas. New York City is lighted by the best gas in the world; I refer to the candle-power of the gas. London has 16 or 17 candle-power gas, Berlin the same, Glasgow perhaps about 20, while New York has full 25. These facts are curious and interesting things for this society to study. We want some of the doctors and oculists to tackle these important questions, which are questions for this society to handle; we want the workers, and if we can get our members to join hands in this work, we will make progress and amount to something as a society.

Now, as to the laws of light in decorations. I am going to touch but lightly on the architectural point. You will go, as I do, into the house of a friend, and you will find in his library, in addition to having his walls stacked with bookcases, that he will have his library ceiling brown or some other horrible color that will suck up all the light. While it is not necessary to make the ceiling absolutely of white, it is certainly of no use to have it of a color that absorbs all the light. These are important questions which suggest themselves to my mind, and I am sure there is plenty of work along these lines for the various members of this society.

Mr. Arthur Williams, The New York Edison Company:

With Dr. Elliott I am inclined to disagree with our President's figures of $200,000,000, as representing the cost of illumination in this country. My opinion is that the cost is more nearly twice this sum. But this only emphasizes the importance of the work of the society.

Dr. Elliott referred to a remark made at the last meeting regarding the light wasted on Broadway. The society should not go astray at the beginning regarding this illumination. Its purpose is advertising, and it should, therefore, be viewed from that standpoint rather than from the standpoint of mere illumination. The percentage wasted is not so great as might be supposed. The lamps are of low candle power, but behind each is a fairly efficient reflector in the white surface of the sign. Possibly many may think that higher candle powers are used.

Lighting engineering as a profession undoubtedly includes the production of lighting effects through the medium of signs. These signs perform a double service—they tell a story or convey a message to the passing public, and at the same time give brilliant illumination. The best way to produce the advertising result desired is to have a bright white light, which, while fixing one's attention, also leaves a pleasant impression. It was with this end in view that the sign illumination of Broadway has been developed. And so interesting, pleasant and striking has it now become that a walk through that thoroughfare is almost equal to a night at the Opera, or an evening at almost any one of New York's plays. In addition to the individual benefit derived

from these signs, there is a very material neighborhood benefit.

Dr. Elliott has referred to the earlier history of municipal lighting in New York City by the Edison and Brush Companies. He is apparently of the opinion that the Edison Company stuck its lamps on high poles high up in the air. But it did not. Following the example of the illustrious man, whose name the company bears, in this matter the company started right. It will be remembered that in all of Mr. Edison's original work we have that which is best in the engineering practice of the present day. The original station contained a direct-connected unit; the water tube boilers; current was supplied by an underground system of mains and feeders, and eventually passed through a meter upon the customer's premises. Likewise, in the matter of municipal lighting, which was started only after the subject was carefully studied here and abroad, the lamps were turned down, and were placed reasonably near the sidewalk and roadway.

The first street illumination of the Edison Company was the lighting of Fifth avenue at the time of the Columbian celebration. And with the exception of a very few streets in the larger cities of the world it was then, and remains to-day, a strikingly successful example of municipal illumination. But one radical change has been made—the substitution of enclosed for open arc lamps.

When our President first spoke of the organization of this society, it seemed to me that there existed a genuine need for it. The opinion I then had to give was most favorable to the undertaking, and it has been strengthened, rather than modified, since that time. I think there is no field in which we can specialize in connection with the electric light and gas industry that has been so completely neglected as that of the lighting engineer. There are seven or eight available methods of illumination, but it is not easy to show which is best for a given purpose. If one should ask about photography—as one of many illustrations—whether it would be better to use the Mercury, Nernst, or the ordinary arc or incandescent lamp, we could say that any one of these could be used successfully, but which one most successfully very few could say with any degree of accuracy. Then there are the methods available for using light. Shall it be obtained from wall brackets or ceiling fixtures, or from a concealed source; how should show windows and show cases be lighted; what is the best method for illuminating department stores of large areas? These are all practical, everyday questions, which I hope the membership of this society shall soon be better fitted to satisfactorily solve than we are at the present moment.

Then again, there are questions of quantity. Some days ago an engineer stated that he had succeeded in equipping a building so as to illuminate it perfectly at an expenditure of 3 watts per square foot of floor space. There are so many divergent factors entering into the question that the figures perhaps convey little of the real meaning, but you can discern the trend of his mind.

The field of the society is national in its scope. And it has occurred to me that diplomas or certificates of membership should be issued to the members, which would become as much of a professional asset as the similar certificate of membership in the American or English Institute of Electrical Engineers.

The President:—There has been some difference of opinion as to the accuracy of the statistics in my address. I think a few words from Mr. T. C. Martin, who got up the 1905 report for the U. S. Census on electric light, will be in order.

Mr. T. C. Martin, Editor, *Electrical World:*—

Mr. President and Gentlemen:—I esteem it a very great honor to find that in the first paper presented before this new body, my name quoted as that of an authority on the subject of illumination. I am very glad indeed that you connected my name with the electric light statistics specifically. I think from the data that I had the privilege of collecting for the Government over two years ago, and applying a rational basis of percentage of increase to those figures, the figures for electric light which you give in your paper are extremely safe and conservative. I am not inclined to agree at all with my friend, Mr. Arthur Williams, who considers that there would be some $50,000,000 or $75,000,000 more. We must not

forget that on account of the reduction in the price of current made by the New York Edison Company, the figures of New York City have taken an enormous jump, so I believe New York City shows an increase in the consumption of current during the past year of something like 20 per cent. Certainly the whole country does not show during the last two years anything like an increase of 20 per cent. in the use of electricity as applied to illumination, and I am glad to confirm the President's statistics in that respect as being near to the facts. In regard to gas, I think it is an understatement rather than an exact statement, but I believe Mr. Marks has investigated this subject in the last month or two with a great deal of care, far more care than I have been able to apply, and until some one like my friend Brown can produce evidence to the contrary, I shall have to assume that the figures given for gas are not much higher than were given in the paper. I think the figures of five or six cities would show that the gas figures are low.

But we are all agreed that this is a tremendously important subject, important to the public and the technical community, certainly important to you gentlemen who once again have gone out from the mother land, and who are creating a new State out on the border line, an Oklahoma or New Mexico in the technical field, as we electrical engineers did in 1884, when our friends of the Civil Engineers and some of the Mechanical Engineers rather decried our enterprise, our rashness, and our enthusiasm and suggested that we should stay within the old lines. There is no doubt that your work is as clearly defined and as well cut, and awaits you as much as the work of the electrical engineers did when we started our Institute twenty-one years ago.

Reminiscences appear to go to-night, and it is of interest for me to say that one of the most intimate bonds of connection between gas engineers and electrical engineers in connection with your work was a gas engineer, who was one of the best friends electrical engineering ever had—I refer to Luther Stieringer, God bless his memory! He was the first man who taught me there was anything like an illuminating engineer, and the incident goes back twenty years. When we remember Mr. Stieringer did the work he did in the gas field, and then came into the electrical field, and taught us the best things we know, I think we should recognize how much we owe him. I love to think that one of the most beautiful memories which Mr. Stieringer left behind him was the spectacle at Buffalo, of the lighting of the Pan-American Exposition, a piece of illuminating engineering which to-day they would find hard to surpass anywhere on the face of the earth. Mr. Edison, who was discussing one evening how the effects at the Pan-American Exposition were produced, said that he could take the carbon filaments that were employed to do that lighting and put them in his derby hat and have room for a few more. If there is such a thing as remembering those who have passed away I should be glad to see the name of Luther Stieringer inscribed on the rolls of this new society, as one who ranked first and foremost as an illuminating engineer.

The aspect of this question and problem has been touched upon from various standards. There are just two that are in my mind. The society has gone out for itself, to treat the problems which confront it upon its own lines, but I would suggest you keep close to the older societies. Our members should seize every opportunity to present papers in the other bodies when they meet. In regard to the National Electric Light Association, I am sure I voice the ideas of Mr. Williams, who is a vice-president of that association, that nothing would be more acceptable to that association than a few papers from the members of this society showing how to improve the product, as to its distribution and utilization. The next point is the difficulty you will have in bringing certain professions into line. I can only speak of my own experience in connection with two buildings, both of them large buildings, worthy of this great city of colossal edifices. In each case I have endeavored to secure the employment of the services of an illuminating engineer, and in each case I have found myself up against a stone wall, I will not say of the apathy or the prejudice, but the inertness of the architect. It was practically impossible to persuade the architect that he needed the services which the membership of this soci-

ety would afford. There is a great opportunity for educational work, and knowing the lines of least resistance we want to follow up the lines of greatest resistance, and do all of our missionary work in those directions.

Mr. Arthur Williams: Pardon me, Mr. President, for speaking again, but I should not like the impression to go abroad that my figures upon the cost of lighting for the country were merely guessed at. They were reached having in mind that the City of New York alone expends about $25,000,000 annually for gas, leaving a little under $12,000,000 for the country at large.

Mr. Martin: Not for illumination.

Mr. Williams:—I am giving simply the basis of my calculations—I understand, of course, that the costs of heating and cooking are included. I have also in mind that the expenditure for gas has been very similar to the cost of electric light. Then again, we must remember the cost of operating the private plants in this country—a cost which is of course much higher relatively than the corresponding price for current bought from the central stations.

I wish we might consider seriously the suggestion of Mr. Martin, seconded by Mr. Brown, regarding the work of Mr. Stieringer. It was my privilege to contrast Mr. Stieringer's work at Buffalo with the lighting effects produced at the Berlin and Glasgow Expositions during the same year. Mr. Stieringer's work did not suffer by the contrast. Many claim that the success of the Buffalo Exposition was contributed to more largely by the lighting effects produced by Mr. Stieringer than by any other single agency.

In addition to Buffalo, Mr. Stieringer, I believe, also planned the lighting effects of the Omaha Exposition. I do not know about Chicago. He was also engaged as the lighting engineer upon one of the new theatres of New York—the first one, so far as I know to hold such a position. I trust that some way may be found in which the memory of Mr. Stieringer may be perpetuated in this lighting field.

Prof. C. F. Chandler, Columbia University, New York.—Mr. President and Gentlemen: I wish to say I am rather overwhelmed by the various problems your President and the other speakers have laid out for the future. As I listened to these various remarks, my mind went back to a time when no one knew anything about electric lighting and gas was a new thing. I was a boy down in New Bedford. Three or four hundred whaling ships were sent out from New Bedford on voyages of three and four years, down into the Atlantic and Indian Oceans, up around Cape Horn, and through Behring Straits and up into the Arctic Ocean, and when these ships returned they brought whale oil, and whalebone, and sperm oil and spermaceti and my friends in New Bedford never dreamed anything could come to interfere with the monopoly they possessed in the furnishing of artificial illumination. It was a lucrative business, and at that time it was said that New Bedford was the richest city in the United States in proportion to its population, and this wealth was derived through chasing whales and frying out whale oil and sperm oil to make artificial illuminants. Sperm oil sold for $1.75 a gallon by the cargo, and $2.25 at retail fifty or sixty years ago, and at that time the cost of artificial illuminants was one of the most serious items in domestic expenses. I remember in my early boyhood when they began to build the gas works at the foot of the street on which I lived. There were gas works in existence at that time but they were confined to a few of the large cities. People came to New Bedford and organized a gas company and I spent much time in watching the operations as they dug the hole for the gas tank, built the benches, set the retorts, and started the works; and when my father actually put pipes into the house and had burners put on the light seemed most marvelous. In my boyhood we had nothing but oil lamps. I have in my museum in Columbia an old brass lamp with a little crooked handle on it, which my grandmother used. She would hold the little lamp between her eyes, and the book she was reading to me, and that was artificial illumination in those days. Then there was an improvement. Some one conceived the idea of substituting camphene, refined spirits of turpentine, and that was introduced as a substitute for sperm oil. It was very inflammable, and devolved a combustive vapor and we had numbers of explosions from it; but it gave such a brilliant light, and was

so cheap, that people burned it and took the chance of the explosion, and the terrible accidents which occurred, for the sake of getting something that was within their means. I do not remember the price, but it did not cost more than one third as much as sperm oil. The difficulty was that it could only be used with a chimney. The turpentine is so rich in carbon that it gives a smoky flame, and it was necessary therefore to burn the camphene in a lamp with a chimney. But an ingenious chemist produced a satisfactory oil for portable lamps without chimneys by combining camphene, too high in carbon, with alcohol poor in carbon, producing the so-called "Burning Fluid" which was used in high-glass lamps, without chimneys, having two plain, unusually long wick tubes. These old "Fluid" lamps are now being sought in all the old attics in New England and sold to the ladies, who have kerosene burners put on them and pretty shades and use them to decorate their tea tables. But I am afraid there must be a factory where they make them, as there are so many of them being discovered and sold.

I went to Germany to study chemistry. When I entered a German family, as a boy, in Berlin, there was a glass lamp placed on the table that held a queer looking oil. It had a smell different from sperm oil, and I inquired of my host what it was and he said it was a "Photogen" lamp. I inquired of my Professor what this new oil was, and he said it was made from boghead mineral, which came from Scotland, and that parties in Scotland had begun to manufacture it on a large scale. I was so much interested, that I immediately sought for information and secured one or two pamphlets which had been published on the subject of this coal oil, giving an account of how the oil was manufactured from the boghead mineral, which came from Torbane Hill, Scotland. When I came home, in 1856, and told my New Bedford friends who had their whale and sperm oil refineries and candle works, about an oil made out of a mineral dug out of the ground, they shook their heads and said that nothing could ever interfere with the prosperity of the sperm oil industry. I was interested in the oil and wrote to the *Scientific American* and offered to write them an article on the new oil which was burned in Germany, if they would promise to publish it, and they wrote back that they did not think any such oil as that would ever interest the American public. In less than three years after that, there was a series of coal oil factories from Portland, Maine, down to Wilmington, Del., manufacturing the so-called coal oil or kerosene. It was made out of the boghead mineral which came from Torbane Hill, Scotland; Albertite, which came from Nova Scotia, Grahamite, which came from Ritchie County, West Virginia, and Breckinridge coal, which came from Breckinridge County, Kentucky. As soon as this coal oil made its appearance, lamps were invented to burn it, and the price of the oil dropped down to 50c. a gallon. The coal oil industry was firmly established and light became much cheaper. Then a couple of Yankees from New Haven went to Northwestern Pennsylvania, where they saw oil on the surface of the ponds, and some of this oil was skimmed off the ponds and taken to New Haven to Prof. Silliman who examined it and said it was nothing but crude kerosene oil. They asked him if it was useful, and he said that it certainly was if they could get enough of it. They went back to Oil Creek, in Pennsylvania, but did not dare to make any very definite bargains with the farmers. They prowled about and found places where there was scum on the water and made contracts with the farmers to gather the oil on a royalty. They gathered a few barrels of it and then selected a man, Col. Drake, and put him in charge and organized the first petroleum company in the world, the Pennsylvania Rock Oil Company. Col. G. L. Drake was made the Superintendent, and went to Oil Creek to take charge of the collecting of the oil. He learned that in 1819 oil was accidentally obtained in boring two salt wells on the Muskingum river in Ohio, and that in 1829 a flowing well was accidentally obtained at Burkesville, Ky. He became possessed of the idea that he might obtain oil by boring for it. So he erected a derrick and started to bore an oil well. The old farmers came from miles around to watch the boring operation, with a feeling that Drake might with equal reason bore for whiskey. But on the 26th of August, 1859,

he "struck oil" at a depth of 71 feet, and obtained 400 gallons which he sold for 50c. a gallon. Soon a forest of derricks sprang up about Oil Creek which extended into West Virginia and Ohio. Successful wells yielded from 100 to 2000 barrels of oil daily. The Noble well yielded in a little more than one year 500,000 barrels of oil; the Sherman well in two years 450,000 barrels, and petroleum became one of the most valuable productions of the United States.

The yield in 1904 was over 100 million barrels. To-day the price of refined petroleum for use in lamps is 5c. a gallon in bulk. When I came to New York in 1864 the price of gas was $3.75 per 1000 feet, and the illuminating power for a five foot burner was equal to 16 spermaceti candles; today the price is $1.00 per 1,000 feet, and the illuminating power for a five foot burner is about 24 candles, and with a Welsbach mantle burner more than 100 candles, and the public always talks about poor gas and high cost. I was in London last summer and was told by the chemist in charge of the City Testing Station that in London the companies were required to furnish only gas of 14 candle-power.

About 1878 Mr. Brush made arc lighting practicable for street railway stations and public places. The same year I had the good fortune to spend two or three days with Mr. Wallace at Ansonia, Conn. He had invented a new dynamo and a new arc light, and he invited Mr. Edison, Prof. Barker, and myself to come and play with them. Mr. Edison became deeply interested in the lighting problem to which he had previously paid no attention. He said much about the desirability of providing electric light in small units for domestic purposes, units of about 16 candle-power, the equivalent of an ordinary gas burner. He went home full of the idea and in less than a year he had invented the incandescent lamp, his improved dynamos, the motor, safety plug, and his feeder systems of distribution. Here was a revolution in artificial illumination. By a curious coincidence a Parliamentary commission, appointed to consider some applications to charter electric lighting companies, called at this time the most distinguished electricians in Great Britain to testify, and Lord Kelvin, then Sir William Thompson, Mr. Price, Mr. Dracon, and others, all said it would not be possible to divide the electric light into small units and even if small electric lights could be devised it would not be possible to divide the electric current so as to properly supply them. Mr. Edison had already accomplished these results.

This is the picture of the past, Mr. President, that came up before me as I listened to your statement of some of the problems for future discussion by this new and promising society.

Mr. E. C. Brown, Publisher of the *Progressive Age:*

Mr. President and Gentlemen:—I was sent a copy of our President's paper, but I was so much engaged to-day that I did not have the opportunity, as I fully intended, to look it over carefully. I should not care at this session, though I desire to do so at a later meeting, to present my figures as to the amount of money expended annually for gas illumination. I should say, unhesitatingly, that probably the cities of Greater New York, Philadelphia, Chicago, Boston, St. Louis, Milwaukee and St. Paul, would quite reach—I am now speaking of illumination as distinct from gas used for heating of cooking and other domestic purposes—would quite reach the sum of $25,000,000 or $30,000,000 annually, leaving the balance of the country to still greatly increase the amount stated by our President.

Leaving that subject, I wish to add a word to what Mr. Martin has so ably stated in regard to Mr. Stieringer. I had a brief acquaintance with him, and I recognized the excellent qualities of mind and heart and the breadth of view which the man had concerning lighting problems. He was a lighting engineer and would, if living, make an ornamental member of this society. To refer to my friend, Dr. Chandler's, remarks, I think he has done this infant society a world of good by talking this evening as an occasion to look forward. We can see what lies in the future, and we should provide for it. All of the improvements in modern lighting which Dr. Chandler has traced today have occurred in the brief span of his life, and to-day we find him actively performing his duties; so that it would appear that the younger men in this society may have still greater possibilities in the field

of illumination, which I hope and believe will be very greatly advanced by the work of the illuminating engineers.

The President:—We have heard from the electrical interests and the gas interests. I think it would be in order to hear from the oil interests, which are also represented. We have with us the expert of the lamp department of the Standard Oil, Mr. W. T. Sterling.

Mr. W. T. Sterling, of the Standard Oil Company:

Mr. President—I am here this evening in response to your kind invitation and I trust you will excuse me from saying anything on the subject of oil illumination, as I did not come prepared, not knowing that I should be called on to say anything. Being interested in the subject of illumination, I came here more to learn the object of your society, and must say that I am glad I came, for I have enjoyed the meeting and have been much interested in the discussion here to-night. At some future time I shall hope to give you either a paper or a talk that may be of interest to the society.

Mr. J. S. Codman, of J. S. Codman & Co., Electrical Engineers:

So far as I know we have been very successful in getting the different interests represented in the Society. I think it is important now that we should do something to create interest in the Society in other places than the City of New York. I think it would be well to consider the possibility of local branches of the Society, or the holding of meetings occasionally in other cities than New York. I have not any specific idea in mind, but I think it may be possible to have local branches at the meetings of which papers presented at the main meeting of the Society can be repeated and discussed, or it may be possible to have separate papers read and published together with the New York papers, or lastly, it may be possible for the regular meeting of the Society to be held in some other city than New York occasionally.

Mr. E. L. Elliott, editor of the Illuminating Engineer:

I think the ground has been pretty thoroughly covered. One aspect of the question, however, occurs to me, and that is the work this society can do in unifying the various interests. The fact that there is a great waste in the use of all light-sources seems to be generally admitted; whether it is to the extent of one-half, or one-third, or one-quarter, the waste is very considerable. It is unquestionably desirable, not only that this waste should be avoided, but that a better quality of illumination should be produced. To this end all the various interests concerned in illumination, from the producer of the illuminant, whether gas, electric current, or oil; the manufacturer of the lamp or apparatus by which that illuminant is converted into light; the manufacturer of the accessories, in the shape of shades, reflectors, or other apparatus, by which the light is distributed, the architect, who generally draws the specifications for the placing of the light-sources; and the decorator, who with the architect has to decide as to the ornamental and decorative features; all of these interests, in order to secure the results that we call good illumination, must be harmonized and must work together to a common end.

The difficulties of dealing with the architect have been set forth; but happily, I think with Mr. Ryan, these troubles are disappearing. He speaks of a change in the last three or four years. I think there has been a change in the last three or four months in this direction; and with what opportunities I have had for observation, the changes are coming rapidly, and the illuminating engineer is becoming recognized as essential in his particular field. The architect works from a certain basis; the decorator works from another basis; the purchaser of gas and of electric current works from still another basis. It is the particular province of the illuminating engineer to harmonize all these, and to bring them together so that the total of all their efforts shall lead to a result which shall be generally satisfactory. By bringing all these interests together, not only in a literary and scientific way in the presentation of papers, but in a social way, the Society should promote the feeling that the various interests are not opposed, but on the contrary are all mutual.

There is one other point I would refer to, and that is the tendency of those producing illuminants to look askance at im-

provements in the way of economy, as lessening their income. I think it has been clearly shown by the remarks, especially those of a reminiscent character, that every improvement looking toward the cheapening of light has increased the total income of those interested in producing light, from the introduction of a cheaper oil than whale oil down to the cheapening of light from gas by means of Welsbach mantles—in every case the effect has been to increase the amount of light used, and incidentally the total income of the various interests concerned; so that it seems there need be no reasonable objection or hesitancy on the part of any interest in producing the very best illumination possible at a minimum of cost.

Mr. F. N. Olcott, of Black & Boyd, fixture designers, being called upon, said: I do not know that I am at all competent to make an address that would interest the gentlemen present, but I do feel vitally the importance of the society in its bearing on our profession. I look for a great deal of benefit to every one allied to the lighting interest from the formation of this society.

The President.—I regret that Mr. Henry L. Doherty is not here this evening. He said he would attend and take part in the discussion. We also expected Mr. G. D. Ramsdell, Secretary of the American Gas Light Association, but he is not present.

Mr. R. M. Searle, of Westchester Lighting Co., Mt. Vernon, N. Y.—

The one thing that impressed me most to-night were the remarks of Dr. Elliott on the interior ilumination in regard to color effects and color schemes. In the practical side of the application of light, one of the greatest difficulties we experience is the adjustment of the cost to the consumer. Dealing with a suburban residential district, as I do, we have many new houses going up, and the entire interior decoration is white plaster at first. A certain unit of light is sufficient for a certain length of time, until the interior decoration is changed, and the demand for increased illumination increases rapidly. For instance, I have in mind several cases where a new home is changed from white plaster—in the library to chocolate paper, leather ceiling, dark greenish ground. leather bronze effect, with a red wall; golden paper in the parlor; a blue room, a green room, and a pink room; the source of illumination for white plaster called for one 16-cp. lamp in many instances, or a Welsbach mantle, and after the paper was put on all they could get was insufficient. I have been up against this proposition frequently in suburban districts. Touching on the lines to which Mr. Martin referred, I do not know of anything which is more difficult than to make an architect have a proper understanding of this question of illumination; he studies economy to get the contract, and the result is that the architect as well as the illuminating engineer is injured in the long run.

Prof. W. D'A. Ryan, Illuminating Engineer, General Electric Co., West Lynn, Mass:—

I would express my appreciation of the care and excellent way in which the objects of our society are set forth by our President, and also the interest and pleasure I have taken in listening to the various remarks. I would say in regard to the architectural situation that that has very materially changed in the last three or four years. Four years ago it was almost impossible to obtain an audience with an architect. At the present time we find inquiries coming in from architects every week, in fact, sometimes two or three in a week, and find they are now looking for information on the subject of lighting; they feel that there is really more to it than merely placing a lamp here and a lamp there, and I would say, from the illuminating engineering department of the General Electric Company, which I represent, that we have more than we can do directly with the architects, aside from our other work. That is an encouraging sign. I feel there are gentlemen here to-night whom the association would probably prefer to hear from, and I shall not take your time.

Mr. H. M. Lauritzen, of the Holophane Glass Company:—

The question of lighting has been taken up scientifically by the company for which I work. It has been their endeavor to take care of the rays of light, that is, to take them from the direction in which they have been useless and bring them to a point where they are needed. In order to do this

they have been compelled to come down to a study of illuminating engineering.

Mr. W. J. Clark, President, National Commercial Gas Association, New York:—

I am not prepared to say anything on this matter to-night, but in regard to incandescent mantle lighting I might say one thing that occurs to me that shows the advantage over flat flame burner. I engaged on the heating and cooking line, and we canvassed among the East Side people where they were using one flame in the kitchen to illuminate the room, living in that room and doing their eating and reading in the room, and we found many flat flame burners which were burning from 12 to 15 feet of gas in an hour. During the time of competition, many Welsbach lights were given away in other sections of the city, and as a canvassing scheme we had some of these brought in and refinished at a cost of one and a half cents each, and gave a Welsbach mantle to these people on the East Side as an inducement to buy a hot plate. We found they could do the cooking with the gas they were wasting with the flat flame burner, and their bills would not be any higher. I am not prepared to speak at any length, but I will say that I remember when the electric light man first came into the field he gave the gas man a chill, and we were very much afraid of him, and speaking in a lighter vein in regard to "The Great White Way," of which Mr. Williams spoke, the electric light man has done something lately towards removing that chill because he has told us that every minute is the time to take a highball, and that helps to take the chill off the gas man.

Mr. John Campbell, of the Electrical Auditing Company, Boston.—I think every interest has been touched on very ably to-night; but there is one which appears not to have been covered, and that is the public. I do not think there is any one who should welcome this society more than the general public. The public takes any information, no matter how accurate it may be, with a great deal of suspicion. They think that there is something concealed. If the public as a whole can feel that there is an able organization that they can depend on for information, back of all that may be said by any independent company or any independent organization, then we are reaching out into a field that will be helpful to every one of us, because we all depend on the public. I think one of the objects of this society should be to keep in touch with the public.

It will not be out of place to add to the discussions which took place at the meeting the following extracts from an editorial in the *New York Tribune*, which appeared on February 14th, the morning following the meeting:

THE ART OF LIGHTING.

It would have been safe to predict that Mr. Louis B. Marks, in his presidential address to the Illuminating Engineering Society in this city on Tuesday evening, would speak about recent advances in the art of lighting, supply statistics showing the extent of the industry, and, inasmuch as the organization of which he is the head is a new one, make some statement of its scope and plans. All of these things he did with an ability which revealed his fitness for the office that he now fills. But he did somethings besides, and this is the more notable because it was not, perhaps, strictly within his province, and hence betrayed an exceptionally humane spirit. Theoretically, the engineer limits his endeavor to the accomplishment of given results with the least material and expense. Taking a narrow view of his functions, the illuminating engineer might say: "I undertake only to show you how to generate a specified amount of light at the lowest attainable cost, and am not responsible for any unpleasant consequences which may attend its use when you have got it." Mr. Marks does not stop at that point. Having recognized the existence of a grave evil, he frankly points it out. The public may well thank him for doing so.

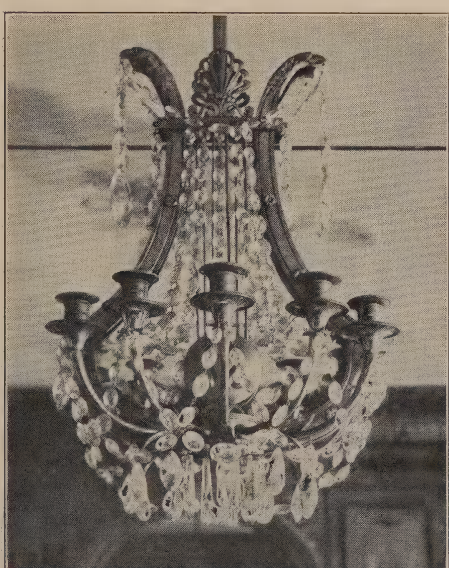
Though much attention has already been given to suitable shades for electric lights, Mr. Marks declares that the great majority of lights are still without them. If either an arc or incandescent lamp is so placed that people will not be obliged to look directly at it, no harm can ensue and shades are not required. When, on the other hand, such lights remain in the field of vision, the eyesight of those who are obliged to face them is likely to suffer. Mr. Marks believes that unshielded 16-candle power Edison lamps in street cars threaten something more than discomfort to passengers. When a man makes use of those on one side of a car in reading and holds his paper so as to hide those opposite him, he experiences no inconvenience, but if he lays down the paper or is without one he is often exposed to a glare that may prove positively injurious to his eyes. Ground glass bulbs would diffuse the light and make it less painful. Their use might possibly discourage reading, but we doubt it.

"Crystal" Effects in Fixture Design

"History repeats itself," particularly in matters of art. The glass chandelier, which but a few years ago was being taken down and relegated to the garret or to the junk dealer, has been rediscovered, and restored to the place of honor in the most elegantly decorated dining rooms of new and palatial hotels, and in the dwellings of millionaires. The return to this earlier form of decorative art is to be particularly commended in this instance, for the reason that it was originally a good form of art; and that which is in truth "a thing of beauty" will in fact be "a joy forever."

LOUIS IV. LANTERN: VERSAILLES.

Perhaps the finest specimens of this class of lighting fixtures are those of the French palaces and chateaux, ranging from the time of Louis XIV to XVI, and through the period known as that of the "Empire." The illustrations show typical forms of chandeliers of this character, selected from a large number of examples.



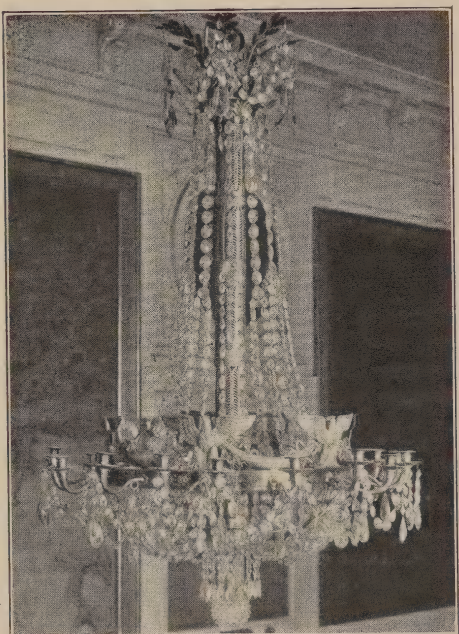
"EMPIRE" DESIGN IN METAL AND GLASS: FONTAINEBLEAU.

All of these examples are highly suggestive as to the possibilities of adapting this method of ornamentation to the construction of electric fixtures, and should prove useful to those seeking highly artistic effects, conformable to the practices of good and efficient illumination.

The art of glass making has been greatly improved since the days of the originals of these designs, far greater brilliancy and clearness of glass being obtained. In this respect it is interesting to note that European manufacturers offer for sale glass having the exact imperfections of these old master-pieces in the fixture line; that is, they offer glass either of a smoky ap-

pearance, or of the slightly purplish tint, which often shows in the older glass. We can conceive of no honest purpose to be secured by the use of this imperfect glass. To imitate a virtue may be excused in accordance with Shakespeare's dictum, "Assume a virtue, if you have it not"; but to imitate a fault, or imperfection due to limitations which no longer exist, is certainly past all condonement.

LOUIS IV., ALL CRYSTAL: COMPIÈGNE.



"EMPIRE" DESIGN, IN METAL AND CRYSTAL: COMPIÈGNE.

BEAUTY VS. UTILITY

The illustration, taken from the cover of one of the popular magazines, shows in a very artistic manner how neglect to consider illuminating effects may lead to faulty result in design.

The table lamp with its art glass shade is undoubtedly a pretty object to look at, but as a reading light the combination is an absolute failure. The area of light which it emits is so limited that the reader must lean over on to the table in order to get the pages of the book illuminated. While this position may be very pretty as an artistic pose, if one were compelled to take this position for an entire evening's reading, one would surely retire with aching joints as a result.

Street Lighting

By Haydn T. Harrison, M.I.E.E.

(*Abstract of a paper read before the* Institution of Electrical Engineers *at Manchester, December 12th, 1905.*) ..

From "The Electrical Review" (London).

The antipathy which engineers have so far shown to the actual measurement of street illumination is, in the case of gas engineers, and, to a smaller extent, in the case of electrical engineers, due to the fact that they are in the habit of stating the value of a lamp as the candle-power which it will give when measured in the best position and without any globes or lanterns; therefore, when measuring street illumination a figure is generally obtained much lower than that claimed.

For instance, a Welsbach mantle consuming from 3.5 to 3.75 cubic feet per hour is generally stated as 70-c.p., whereas the very large number of measurements I have made during the last few years have shown that the average candle-power derived, when measured in the street, is 35. Again, a 200-volt ½-ampere "A" type Nernst lamp, according to the makers, gives 70 candle-power (heffner units), in practice I have found them equal to 37 candle-power.

Again, a 500-watt direct-current open type arc lamp is generally called a 1,000-c.p. lamp; whereas Mr. Bradley's tests and my own go to prove that they average 600 candle-power. Another example is the new gas lamps in Fleet street, which were claimed as 200 candle-power, whereas the actual measurements I have made prove that they average 135 candle-power.

Another example is the much-advertised gas lighting in Kingsway and Aldwich. The gas journals are continually referring to the lamps used as 1,000 candle-power, whereas the average of a large number of photometric measurements made by myself and others prove that the average candle-power in the street is 515.

In order to arrive at any decision as to the degree of illumination which may be considered efficient for various streets, it is necessary to decide first the units in which the value of illumination should be specified. The mean illumination of a street cannot be ascertained from measurements of candle-power, unless these are taken at a large number of different angles; moreover, it is necessary to state the height and distance of the lamps, in order to judge the illumination derived.

In 1892 Mr. Trotter read a paper before the Institution of Civil Engineers which dealt very fully with the matter, and his paper is even now probably the most complete treatise on the subject extant. Mr. Trotter used an illumination photometer devised by himself, in conjunction with Sir William Preece, by which the horizontal illumination at various parts of the road could be measured.

There are practical objections to the use of an illumination photometer as described by Mr. Trotter, which eventually resulted in my abandoning its use, but not until I had had practical experience of it for a period of about two years, and had obtained results of considerable value to me in my study of street lighting.

In order to judge the lighting of a street it is only necessary to know the minimum illumination at any point where light is required, because if that illumination is sufficient for the purpose, it obviously follows that it will be ample elsewhere.

It will probably be suggested that the value of the maximum illumination should also be measured and stated, in order that a diversity factor may be arrived at. The best lighted streets are those with the highest minimum illumination and with the lowest diversity factor, and, after having granted this definition, all that remains to be done in comparing the lighting of various streets is to state the value of the

maximum and minimum illumination as measured therein.

But the unit of illumination, namely, candle-power feet, is not sufficiently definite, for it is obvious that when speaking of illumination we really mean the degree to which something is illuminated, and that will depend to a very large extent on the average angle at which the light strikes the various surfaces of that object.

In the design of instrument I recommend, an angle of 45° has been chosen; if it had not been for practical reasons, I would have preferred a vertical screen. I abandoned the horizontal screen, which I used for many years, because the angle of incidence when measuring at a distance from the post became so large as to reduce the illumination on the screen to that point when it was difficult to get a balance, and, moreover, unless the screen was accurately leveled, considerable errors were liable to creep in; these faults made it practically impossible to measure the minimum illumination, which I consider the most important factor.

Other reasons of equal importance are that, owing to the great variation in the spectrum of lamps used for street lighting purposes, a flicker method of obtaining a balance is essential for accurate work, and an angle of 45° is found more convenient in the design of this part of the apparatus, and that the illumination of vertical objects in a street is of equal, if not greater, importance than that of the road and pavement. Therefore, by stating the value of the illumination on a screen at an angle of 45° we are probably giving the most useful information for practical purposes. Moreover, the measurement obtained at this angle are as easily converted to measurement of candle-power as would be the case if any other angle were used, and the fact that the candle-power of the lamps in one direction only is measured simplifies this calculation considerably. The most convenient height for making the measurement I have found to be 4 feet.

Therefore, for the purpose of measuring and comparing the illumination of streets, roads or open spaces, I would suggest that the minimum and maximum illumination, which can be derived at any point, be stated in units of candle-power feet measured on a plane surface inclined to be vertical at an angle of 45°.

I have, from various published statements, obtained the opinions of gas and electrical engineers as to the present-day requirements in this direction, and from tests made by myself and others am able to give a rough average of what actually occurs in practice.

From the valuable tests taken by Mr. Pearce at Manchester, I have extracted the following figures, which give an example of the lighting of main thoroughfare of an important town (see Table I.) :—

A much more interesting example in this neighborhood is that of Gorton, where Mr. Pearce has lately replaced 25 double Welsbach mantles, each taking 4 cubic feet of gas per hour, by 22 enclosed arc lamps giving 400 candle-power each. The gas lighting in this case used to cost £150 per annum; the electric lighting is done for £176. Taking an average candle-power for the lamps based on the figures given by Mr. Price, of Birmingham, and measurements made by myself elsewhere, the candle-power will work out at 80 per post, therefore it will be seen from the following figures that the minimum illumination has been increased four times at an extra cost of 17 per cent. per annum:—

Old System.—Incandescent gas, 80 candle-power, 90 feet apart, minimum illumination (direct), .037.

New System.—Enclosed arc lamps, 400 candle-power, 100 feet apart, mimimum illumination (direct), .145.

As a final example, I propose to take the much disputed City and Kingsway lighting. In the case of Kingsway, the length is 4,000 feet and the breadth 100 feet.

There are 51 high-pressure gas lamps, and the measurements I had made in October averaged 670 candle-power on the lamps in good condition, and 450 on those which were in poor condition. The posts are staggered, therefore the maximum distance from any post would be 46 feet where you would be deriving light from three sources, two of which would be available on a screen at an angle of 45°, but, for the sake of comparison, I propose to consider one only. This works out as follows:—

Kingsway.—High-pressure gas, 515 candle-power, 80 feet apart, minimum direct illumination, .206.

In the case of Fleet street, 12 10-ampere lamps in muranese globes have lately been replaced by 34 pairs of incandescent gas mantles.

In the case of the gas lamps, the two mantles are placed side by side, therefore the minimum candle-power measured is across the road, where it averages 80 candle-power, and this will be the point at which the minimum illumination occurs, namely, at a distance of 30 feet.

The old arc lamps were at a distance of 137 feet apart, and, as they gave 680 candle-power when measured at a distance of 30 feet, it can be taken for granted that 600 would be a safe average to take at the greater distance.

City, Fleet Street.—Old arc lamps, 137 feet apart, minimum direct illumination, .117. New gas lamps, 48 feet apart, minimum direct illumination, .08. The actual minimum illumination between the gas posts would be 48 feet apart, minimum direct illumination, .18.

I think I have now given sufficient opinions and examples to formulate some idea of both the past and present practice. The very figures which I have put before you show the diversity of opinion, as demonstrated in practice; it is therefore only possible to obtain a rough average, but, nevertheless, this will form some basis to work on.

I do not propose to consider the more brilliantly-lighted streets of Manchester, or the gas company's latest show in Aldwych and Kingsway, as there is little doubt that the illuminating of public buildings in the case of the former has been aimed at as much as, if not more than, lighting the streets; and the latter case, as far as one can judge, is an advertisement for the gas companies, the cost of which will probably never be disclosed. Therefore, I think we may take it that in most towns the minimum direct illumination is as follows (see Table II.):—

These figures are averaged from actual measurements made in the street, and not from the fictitious values often claimed, and it is interesting to note that in many places where electric light has been installed, these values have been exceeded, wheras the actual illumination obtained from gas mantles is generally much lower than that estimated by the representatives of the gas industry.

The usual test for the value of the minimum illumination is the possibility of reading a Bradshaw railway guide. I find, personally, that this is possible at an illumination equivalent to .05 candle-power feet. With .005 candle-power feet, you cannot recognize a face; in fact, can only just avoid running into anything. Mr. Trotter found moonlight to be .028 candle-power feet in England near full moon; thus it will be seen that in the side streets of large cities the minimum illumination approaches full moon, but in the suburban street is less than one-fifth. Unless the value of illumination in any street exceeds, say, .015 candle-power feet, it could hardly come under the head of street lighting, but should be called "beacon lighting," as suggested by Mr. Trotter.

The remainder of my paper I intend to give up to discussing the possibilities of improving the existing state of affairs without increasing the cost in any way. It is now several years since I came to the conclusion that the efficiency of street lighting must be judged by the minimum illumination derived at any point, and I devised fittings to increase the light at that point. By far the most efficient of these, which is fully protected, is now being manufactured by the Reason Manufacturing Co., of Brighton. In designing these fittings, I took the following facts into consideration:—

1. That the rays directed above the horizontal are useless, and therefore can be diverted up and down the street to increase the distant illumination.

2. If the posts are erected on the edge of the footpaths, the rays which would illuminate the adjacent houses or fields are practically useless, unless the houses have a reflecting value, which is very rarely the case.

3. The rays of light illuminating the street near the post should be of small value compared to those directed to a distance up and down the street, in order to obtain even illumination.

The above conditions, in short, mean that practically only a quarter of the mean spherical candle-power is useful, and that the other three-quarters are wasted unless directed into the required direction. The extent to which this fitting succeeds is as follows:

The average candle-power of the lamps measured from all parts of the street will be found to be 2.2 times the mean spherical candle-power, and the maximum candle-power measured over the width of the road some distance from the post is nearly three times the mean spherical, the minimum candle-power measured adjacent to the post being equal to the mean spherical candle-power of the lamps.

I have had to divide the source of light into two; in other words, to use two lamps in place of one.

One-half of the filaments or glowers of each of these lamps is enclosed in a specially shaped hollow hemispherical reflector, fixed at such vertical and horizontal angles that in those positions (as viewed from the street) where the reflectors are not in themselves increasing the illuminating value of the lamps to more than double the maximum of one lamp, the light of both lamps is allowed to shine. Thus, at no point does it decrease the light, and over the greatest area of the street the light is increased to the maximum above stated.

These reflectors are of glass blown on to a mould of the correct shape, and in such a way as to form a bottle, the inside of which is silvered; the opening is then hermetically sealed when fixing the cap; thus a reflector of about 88 per cent. efficiency is obtained, which efficiency is practically permanent.

In the reflector the whole of the hemispherical rays are deflected, whereas in previous designs in which the lamp passed through a hole in the center of the reflector, a great number of these rays were not utilized. Another point is that the lamps are in such a position that the maximum rays are used both in illuminating the distant parts of the street direct, *and* by means of the reflector.

These fittings are free from what is sometimes called "the bull's-eye" effect, as the maximum rays are not concentrated into anywhere near a parallel beam, but are spread over an angle of 20°, and rays equal to twice the mean spherical candle-power of the two lamps are spread over an angle of 40°, which is generally the whole width of the road at a distance equal to twice the height of the post.

In order to ascertain the type of lamp to use for the purpose, when basing calculations on minimum illumination, it is necessary to know the candle-power derived from the lamps at an angle of about 20° to 30° below the horizontal, and about 10° on the path side and 30° on the road side, of an imaginary line drawn parallel to the curb; this is, of course, for posts erected on either side of the road, which is the present-day practice.

The following table is based on the average of a larger number of measurements made in the street under working conditions (average mean candle-power of lamps 20° to 30° below horizontal, and 10° one side and 30° the other side of the line drawn parallel to the street) (see Table III.) :—

I would particularly call attention to Class 13, which appears unduly high. In my opinion this is due to the mantles being renewed at more frequent intervals, as it is based on measurements made in Fleet street which may be called without prejudice a test case.

It is now comparatively easy to set down the numbers of posts and fittings per mile necessary to obtain the minimum illumination generally provided for various classes of streets (see Table IV.).

The foregoing table demonstrates several interesting points, the importance of which, I consider, cannot be over-rated. They are as follows:

1. The use of large units of light for general street illumination is expensive, and should be avoided where possible.

2. The cost of maintenance is very often as high, if not higher, than the cost of electrical energy or gas; it must be borne in mind that in the foregoing table electrical energy is taken at 1½d. per unit—it is very often less than this for street lighting, in which case the cost of maintenance becomes a still more important factor.

In calculating the cost of electrical energy when using carbon incandescent lamps, I have taken the lamps as consuming 4 watts

per candle-power—which is reduced to 2 watts per candle-power, or even less, by the Reason fitting; but, even if no special fitting had been used, four 10-c.p. lamps consuming 160 watts are, when placed at 20 feet apart, better than 160-c.p. lamps spaced at 80 feet, as the ratio of minimum illumination derived is 16 to 1, whereas the efficiency of the lamps is only 4 to 1.

The highly efficient incandescent types of lamps which are now being put on the market, such as tantalum and osmium, are much more suited for low voltage than high; these lamps, provided their lasting properties are improved, are eminently suited for street lighting, on account of their high efficiency and steady light-giving power.

I have, therefore, lately been experimenting with them connected in series, with most gratifying results, and trust shortly to be able to recommend the supply of these lamps for street-lighting purposes. They will be low voltage (10 to 30), with thick filaments, intended to be run in series throughout the street, and controlled at the end of each series by a magnetic relay switch connected to the previous series, in a similar manner to that used for arc lighting by Mr. Robinson, of Hackney, and others.

A very simple cut-out designed by myself prevents a fault in any lamp extinguishing the series.

In my calculations it is easy to see that I have not favored electricity in any way. In taking the cost of gas at 2s. per 1,000 cubic feet, I have taken a price which only 12 towns out of 223 are able to charge, all the others being higher; whereas 1½d. per Board of Trade unit is higher than is being charged by a large number of electrical undertakings.

The Chairman (Mr. S. L. Pearce) said, with regard to measurement of illumination, the practice in Manchester was to measure the candle feet at various distances from one point and plot a curve, then turn the photometer round (and plot an adverse curve, and from these two curves a third one was obtained. He agreed with the author that it was better to have a number of smaller units than a few large ones, but this could be carried too far.

Prof. Schwartz thought the author had disregarded some matters of fundamental importance. Quality of light was a thing to be considered; also color, steadiness and intrinsic brilliancy. The human eye had been developed under sunlight. Sunlight was white only about high noon, later it became yellow, and before sunset red. Sunlight never became blue or green like the Welsbach light, and the best artificial light was that which inclined to yellow. If a spectrum of sunlight were examined, it would be found that 80 per cent. of the total luminosity lay in the yellow rays. He had found that a horizontal card of sunlight 25 candle-power per square inch. This intensity was too much. Since globes had been used for arc lamps, the distribution of light was better, and enabled people to see better. The reflector mentioned in the paper would treat the public to a higher intrinsic brilliance than they wanted. Diversity factor was not properly represented by stating the minimum value of illumination. The power of seeing was what they ought to aim at, not quantity of illumination. In some towns there was more illumination than was necessary, though this was not altogether the fault of electrical engineers; it had been forced upon them by the gas companies, who had increased the illumination, and, if electricity had to have a share in public lighting, it must beat the gas. With regard to the author's statement that Mr. Trotter's method of plotting these curves. About 12 years ago he put down the arrangement of lighting at St. Pancras referred to by the author.

Mr. Newbiggins (gas engineer to the Manchester Corporation) said he did not know on what grounds the author claimed that electrical engineers had less to fear from exposure as to the difference between actual and stated candle-power of a given lamp. On the author's own showing a 1,000-c.p. arc lamp only gave 600 candle-power. As to unsteadiness, this was exemplified by the unsteady burning of the arc lamps in the lecture room that night, which was in great contrast to the steady burning of an incandescent gas lamp. He agreed with the author on the value of photometric testing. If these tests were carried out on a 1,000-c.p. gas lamp, and a 1,000-c.p. arc lamp for several hours, it would be found

that the gas lamp would give a much higher efficiency. Gas engineers had used the photometer more than electrical engineers, as they were compelled in many cases to supply gas of a certain quality. In the case of arc lighting, all the light was reflected downwards, whilst in the gas lamps some of it was reflected upwards. It was from the general lighting effect that the different methods of street lighting would be judged. He would like the author to show an electrical undertaking in existence which was able to make a profit at 1½d. per unit, but a gas company could sell at 2s. per 1,000 cubic feet and make a profit. Referring to the figure £7 for maintenance ot high-pressure gas mantles, there was no such figure. If the author had started at 45s. and gone down, he would have been nearer the mark. His own opinion was that the question of respective values of street lighting could best be solved from the points of both effectiveness and cost by each having a street or square allotted to them, and taking an account of the capital outlay, maintenance and consumption (measured by meter) of current or gas, and he would say that gas would work out much cheaper and be more effective. The figures given in the paper were, as far as they related to gas, both fallacious and misleading.

Mr. Andrews thought the question of illuminating the houses in the street worthy of consideration. He noticed that in some of the streets lit by incandescent gas, the light was all on the street and the houses looked quite black, whereas in those lit by arc lamps the buildings were better illuminated.

Mr. D. L. Sands said he could see no reason for placing the photometer screen at an angle of 45°.

Mr. Harrison, replying to the discussion, said that in several small towns gas engineers never used the photometer at all. In places where he had been called in to advise impartially on the question of the lighting, he had often asked the gas engineers if they had taken photometer tests, and invariably their reply was that they did not believe in them. He thought he had been misunderstood as to his opinion of the man in the street. He laid a big value on his opinion. Replying to Mr. Newbigging, he would guarantee a 500-watt d.c. arc lamp to give 1,000 candle-power at a certain angle, and with regard to the arc lamps in St. Pancras going to the scrap heap, he stated that 5,400 incandescent lamps in the district had been replaced by 1,000 arc lamps. Two large companies in London were charging 1½d. per unit for lighting, and made a big dividend. Unfortunately, they did not have the advantage of huge gas holders, such as the gas manufacturers had.

Table I.

Position.	Lamp.	Distance apart.	Minimum direct illumination.
Cheetham Hill Rd	900-watt enclosed arc	76 ft.	.62
Piccadilly	Intensified gas	58 "	.38
All Saints'	600-watt enclosed arc	57 "	.54
Albert street	Intensified gas	102 "	.14
Sackville street	600-watt enclosed arc	66 "	.30
Piccadilly	Incandescent gas	206 "	.013

Table II.

Main thoroughfares, minimum direct illumination	.050 candle-power feet.
Side streets, " " "	.025 " " "
Suburban streets, " " "	.005 " " "

TABLE III.

Electric lamps.	Watts consumed.	Candle-power at angles stated.
(1) Flame type	400	1,300
(2) Open type arc	500	500
(3) Enclosed arc	1,000	1,100
(4) Enclosed arc	600	550
(5) Reason fitting incandescent lamps	200	120
(6) Reason fitting incandescent lamps	120	70
(7) Reason fitting incandescent lamps	60	30
(8) Reason fitting Tantalum lamps	70	110
(9) Nernst lamps "A" type	100—120	40
(10) Nernst lamps "B" type	50—60	15

Gas lamps.	Gas consumed per hour.	Candle-power at angles stated.
(11) High-pressure mantles	30 c.f.	515
(12) High-pressure mantles	20 c.f.	215
(13) Intensified gas, two mantles (City)	7.5	130
(14) Two low-pressure gas mantles	7.5	75
(15) One low-pressure gas mantle	3.75	37
(16) One low-pressure gas mantle	3.2	32

TABLE IV.

DISTANCE APART OF LAMPS OF VARIOUS TYPES TO GIVE REQUIRED MINIMUM ILLUMINATION.

Type of lamp.	Main thoroughfares. Min., .05 c. p. f.		Side streets. .025 c. p. f.		Suburban streets. .005 c. p. f.	
	Distance apart.	Posts per 1,000 yards.	Distance apart.	Posts per 1,000 yards.	Distance apart.	Posts per 1,000 yards.
Electric flame	300 ft.	10	—	—	—	—
Open arc	200 "	15	—	—	—	—
Enclosed arc	300 "	10	—	—	—	—
"	200 "	15	300 ft.	10	—	—
Reason fitting	100 "	30	140 "	21	300 ft.	10
"	70 "	43	100 "	30	250 "	13
"	45 "	66	65 "	46	150 "	20
"	90 "	33	130 "	23	290 "	10
Nernst lamp	55 "	54	75 "	40	189 "	17
"	—	—	65 "	46	110 "	27
Gas Lamps.—						
High pressure	200 "	15	300 "	10	—	—
"	120 "	25	180 "	17	—	—
Intensified	100 "	30	140 "	21	—	—
Ordinary	75 "	40	105 "	28	240 "	12
"	50 "	60	75 "	40	170 "	17
"	45 "	67	70 "	43	150 "	20

THE ILLUMINATING ENGINEER

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Practical Problems in Illuminating Engineering

By Arthur A. Ernst.

I.

"Example is better than precept." The quickest and surest method of becoming familiar with the theory and technology of a subject is to take a number of concrete cases, and work out the various theories in actual practice.

Although illuminating engineering has become recognized as a definite branch of applied science, the technology of the subject is still in a more or less incomplete and incoherent state, and the engineer who takes up for the first time the lighting of a building as an engineering problem, will generally be quite at sea as to how to begin. While it may be true, as has been stated by those who can not see the necessity for considering illumination as a distinct branch of engineering, that it not an exact science, it is based upon exact scientific principles, and therefore as nearly an exact science as many of the other branches of engineering. The purpose of the present series of articles is, therefore, rather to show possible methods of procedure than to lay down categorical rules to be followed without deviation. As in other engineering problems, there are usually a number of different ways of accomplishing the desired purpose, which will bring practically the same final results; but if one method is well understood, the alternative methods may be left to the ingenuity and discretion of the individual engineer.

The problem before us is the illumination of a modern building to be used as the general office and "central" of a telephone company in one of the large cities. The various purposes to which different parts of the building are to be put afford particularly favorable conditions for the study of various problems in illumination.

We will begin with the ground floor plan, the outline of which is shown in Figure 1. The first thing to be considered is the fixed or prescribed conditions. These are:

First: the plan of the floor and height of ceilings as laid out by the architect;

Second: the purpose for which the various rooms are to be used;

Third: the luminant, or means of producing the light.

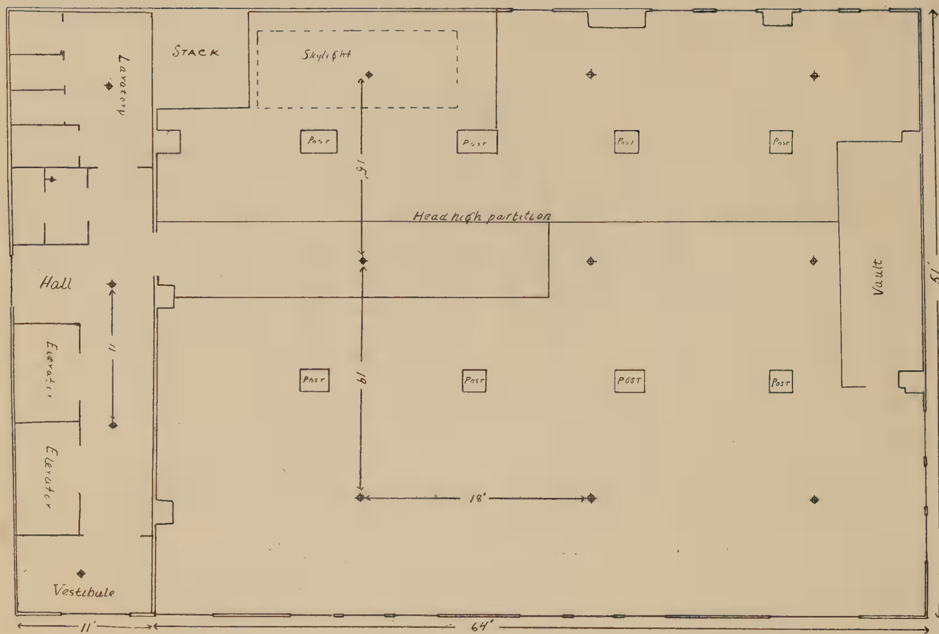


FIG. 1.

Starting from these fixed conditions, we must determine:

First: the requisite intensity of illumination on some assumed or real surface in each room;

Second: the location of the light-sources;

Third: the candle-power and distribution of the light units.

The first condition to be settled is the question of intensity of illumination. It is on this particular point that the lay mind is usually most seriously confused, owing largely to the loose and ambiguous manner in which the various terms expressing light-measurements are used. The term "candle-power" suggests at least a definite idea, on account of the familiar 16 candle-power electric lamp; but the term "foot-candle" is absolutely meaningless to the layman, and expresses but a vague idea to the average architect and engineer; yet it is precisely this measurement that is the foundation and starting point in practical illuminating engineering. A very definite comprehension of the meaning of the term and of the varying values may readily be obtained with no more apparatus than a 16 candle-power electric lamp and a flexible cord. A lamp of this rating gives an average of 16 candle-power intensity sidewise; if such a lamp, therefore, is held at one foot from a surface, as shown in Figure 2, every point on the surface will receive a ray of 16 candle-power intensity, at a distance of 1 foot from the source, and is, by the definition of the term, illuminated with a brilliancy of 16 foot-candles. As the intensity of light varies inversely as the square of the distance, if the surface be removed to 4 feet from the light, as C D, Figure 2, the illumination will be 1/16 as great, or 1 foot-candle. Thus, by varying the distance of the lamp from the surface, different degrees of brilliancy of illumination can be obtained, which are exact enough to familiarize one with the appearance of the different values.

It must be remembered, however, that the measurements as given by this method are measurements of the il-

lumination received by the surface. The apparent brightness of intensity of illumination of the surface as seen by the eye depends not only upon the amount of light falling upon the surface, but upon the amount of light which the surface reflects to the eye. More scientifically expressed, it depends upon the brilliancy of the image on the retina. This visual intensity, which is the final result that we are after, is therefore the intensity of illumination received, multiplied by the coefficient of reflection of the surface illuminated. This simple fact is often lost sight of in estimating the intensity of illumination required.

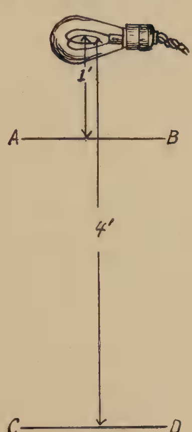


FIG. 2.

A few simple experiments will make this matter clear, and also bring out its importance. Place a 16 candle-power lamp in a horizontal position 4 feet above the surface of a table; the table now receives one foot-candle illumination. Now place on the table a sheet of white paper or white cloth, and note the appearance of brightness; then replace this with a dark colored cloth, and note the apparent dimness. It will be seen by this that an intensity that would be entirely adequate on a marble floor would appear very dim on a floor covered with a dark colored carpet. In the first case the reflection from the surface may be taken as .75, the apparent, or visual intensity of illumination being therefore ¾ foot-candle; while in the latter case the reflection may be .25, or even lower, and the visual intensity therefore only ¼ foot-candle.

The prime factors in determining this question of intensity is, therefore, the purpose for which the room is to be used, and the color of the surfaces which are the special objects of the illumination; having this given, the determination then is a matter of judgment based upon actual experience. In our present example, the rooms are all to be used as office rooms. Desks for bookkeeping and correspondence are to be placed as may be found most convenient, and may be re-arranged from time to time to suit varying conditions. The principal plane on which to figure the illumination is therefore a real one, namely, the tops of the desks. The illumination on this plane may be produced either by local lights, that is, lights attached to the desks themselves, or placed in their immediate vicinity; or by light-sources advantageously distributed throughout the room and attached to the ceiling or side walls. Both experience and theory agree that there is but one satisfactory method of lighting a desk, and that is by providing a light-source for each individual user. The proper light for writing must come from the left and slightly in front of the paper, and the light-source should be provided with a reflector-shade, which, while directing the light upon the paper, entirely shields the eyes from the direct rays. The intensity should be not less than two foot-candles, nor more than three. It is a mistake often made to use too great an intensity of light for writing or reading. White paper, especially the highly glazed paper so commonly used at present for book printing, as well as the finely finished writing papers, is an exceedingly good reflector, producing a considerable amount of direct reflection as well as the diffuse reflection; and a strong light thrown upon such a surface produces a glare which is uncomfortable and injurious to the eyes.

The general scheme, therefore, in the present case is to provide an individual lamp for each desk or operator, and an independent set of lights for the general illumination of the room. In this case the general illumination should be very mild, only just sufficient to enable the various objects and

passages in the room to be readily seen. One-half foot-candle on the floor will be sufficient. The light-sources for this general illumination must also be diffused to a high degree in order to avoid glare. For the desk lights in the present case the only method is to provide a sufficient number of outlets in the floor to enable the desks to be connected in whatever position it may be found most convenient to place them.

To supply the general illumination of the room we have to consider:

First: Symmetry with reference to the architectural features;

Second: The distribution and candle-power of the light-units to be used in order to provide the desired general illumination.

In the present case the electrical engineers of the building have recommended the use of the G. E. high efficiency units for all positions in which they can be advantageously used; a recommendation which the illuminating engineer can very cheerfully endorse. The old method of determining the candle-power to be installed, was to either apportion a certain candle-power per cubic foot of space, or per square foot of surface. Either of these methods is little better than a simple guess at the matter. In the first place, the figuring was based upon the rated candle-power of the lamps; for example, a lamp rated at 16 candle-power was taken as actually giving 16 candle-power. As electric lamps are rated by their mean horizontal instead of their actual candle-power, and as they vary considerably in their total candle-power, although having the same rating, the inadequacy of this method will be readily appreciated. If the method is to be used at all, the total or mean spherical candle-power of the light-source should be used instead of horizontal, or rated. Furthermore, the effect of globes and shades was entirely neglected, which threw out what little value there might be in such calculations. The only basis of calculating that is worth the labor, or is worthy to be called a calculation, is that based upon the distribution curve of the light in connection with its accessory. Our first step, therefore, in determining the specifications for the light units is an examination of the distribution curves of the various units from which a selection is to be made. As the G. E. high efficiency unit has been selected in the present case, we have our choice between the two classes of distribution furnished. The curve of wider distribution, shown in Fig. 3, will naturally be selected.

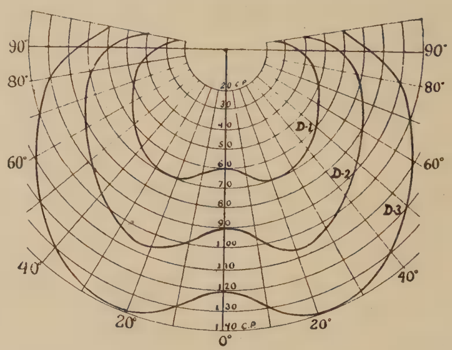


FIG. 3.

In order to determine the intensity of illumination produced on a given surface at any given point with reference to a light-source of known distribution, the following formula is used:

Intensity of illumination equals the quotient of the candle-power divided by the square of the distance of the light above the surface, multiplied by the cube of the cosine of the angle at which the ray strikes the surface.

Reducing this to an algebraic equa-
ducing this to an algebraic equation:
tion:

$$I = \frac{C}{H^2} \cos^3 A$$

Thus, in Fig. 4, the intensity of illumination received at the point P′ on the horizontal surface S S from the light L at a distance H from above the surface, is the candle-power *intensity of rays* in the direction of L P′ di-

vided by the square of the height H (measured in feet) multiplied by the cube of the cosine of the angle A. As this formula is one which will be constantly used, a table showing the values of the cubes of the cosines of the various angles will be a great convenience. In the following table these values are given for angles from 1 to 72°.

ANGLE.	$\cos^3$.	ANGLE.	$\cos^3$.
1	1.000	37	.509
2	.998	38	.489
3	.998	39	.469
4	.993	40	.449
5	.988	41	.429
6	.983	42	.410
7	.978	43	.391
8	.971	44	.372
9	.963	45	.353
10	.955	46	.335
11	.945	47	.317
12	.935	48	.300
13	.925	49	.282
14	.913	50	.265
15	.901	51	.249
16	.888	52	.233
17	.874	53	.218
18	.860	54	.203
19	.845	55	.189
20	.829	56	.175
21	.813	57	.161
22	.797	58	.149
23	.780	59	.137
24	.762	60	.125
25	.744	61	.114
26	.726	62	.103
27	.707	63	.0936
28	.688	64	.0842
29	.668	65	.0754
30	.649	66	.0671
31	.630	67	.0596
32	.610	68	.0526
33	.590	69	.0460
34	.570	70	.0400
35	.550	71	.0345
36	.529	72	.0295

With this table we are now prepared to determine the necessary candle-power of the units, and their heights and relative distances apart; or if, as in this case, there are special structural reasons for placing the units in given positions, to determine the necessary candle-power of the units to produce the desired intensity.

To begin, make an estimate of the candle-power required, and determine whether the candle-power of the light thus assumed is too great or too low. If too great, a second trial is made to determine how much it should be reduced. Thus, by making a few experiments, and determining the results, the correct candle-power can soon be arrived at. If this method of working appears unscientific, let it be remembered that weighing with balances is carried out by exactly this method of guessing and eliminating. After a little practice, furthermore, it will be found that the first guess will be surprisingly near the truth; just as the experienced manipulator will guess nearly at the weight of a body. For the general illumination of the room, as we have already said, a very mild intensity is desirable, one-half foot-candle being ample to enable one to see ordinary oak furniture plainly and without its appearing either unduly dark or bright.

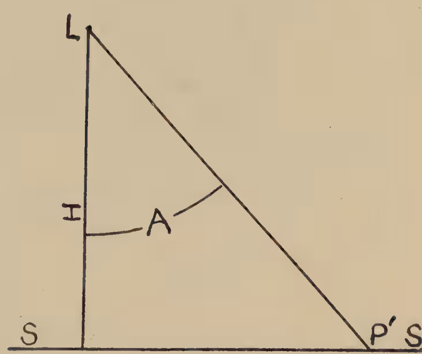


FIG. 4.

In regard to symmetry, either the room may be considered as a whole, or as made up of divisions outlined by the columns. In the present case, as the general effect is to be that of a single large room, it will perhaps be best to place the lamps symmetrically with regard to the ceiling taken as a whole. Such an arrangement is shown in the diagram, Fig. 1. As the ceiling on this floor is 16 feet high, there is an opportunity for varying the height of the lamps within considerable limits. Let us assume for trial a drop of 3 feet from the ceiling, or 13 feet from the floor.

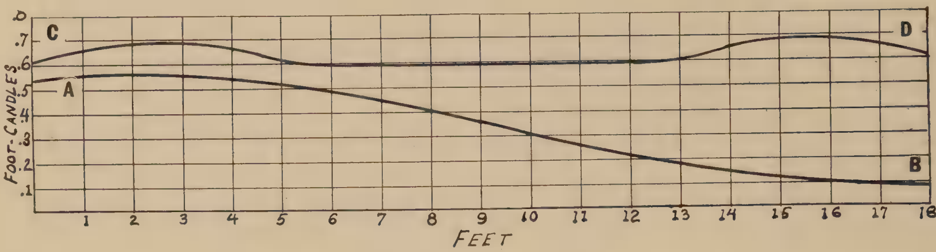


FIG. 5.

Taking now the No. 3 unit, we compute the intensity of illumination on the floor directly underneath. This proves to be .54 foot-candles. We will next determine the intensity produced on the floor at a distance of 18 feet; that is, at a point directly under the adjacent lamp. By drawing a right-angle triangle having a base equal to 18, and a height equal to 13, we find the angle of this ray to be 54 degrees. Taking the intensity of the light at this angle from the distribution curve, we find the resulting intensity to be .07 foot-candles. It will be seen that the intensity falls off so rapidly that it is hardly worth while to make computations beyond this angle. Making similar computations at intermediate angles, we can lay out the curve of intensity, A B, Fig. 5. To obtain the illumination from two lamps, we plot a similar curve, C D, Fig. 5, made by adding the values of the illumination at each point. By this last curve we find that the illumination is approximately uniform, and is somewhat above the minimum which we have established, and is sufficiently near the theoretical requirements for all practical purposes. There will be a slightly less minimum at the center of the squares formed by four lamps, but it will be seen that these points are in comparatively unimportant positions. The arrangement of lamps, therefore, as shown may be considered as conforming to the requirements of the problem. In the hallway and vestibule the No. 2 units will be found to give a sufficient illumination.

There will be a space by this arrangement along the outer walls that will receive considerably less illumination; but as the side walls are largely taken up with windows, which, except in total darkness, will produce more or less illumination, and as files or desks are not likely to be placed around the walls, it is not essential that the general illumination in this position be kept up to the maximum.

In these calculations we have taken no account of the additional illumination produced by reflection from the walls and ceilings. As reflectors are used over the lamps, and as the desks and furnishings of the room will naturally be of a dark color having little reflective power, it is best to neglect this factor altogether.

"G.E.M." INCANDESCENT UNIT.

The Illumination of the New York Hippodrome

By E. L. Elliott.

Among the notable buildings that have been erected in New York City within the past few years perhaps none has attracted more general attention than the theater building known as the Hippodrome. Since theater buildings are always viewed by artificial light alone, their illumination is of special interest. The Hippodrome is claimed, probably rightfully, to be the largest and most expensive playhouse in the world. It will seat 5,200 persons, and represents an outlay of $1,750,000. The stage alone is larger than many a whole theater, being 200 feet wide between walls, with a total depth of 110 feet. It fronts the entire block on Sixth avenue between Forty-third and Forty-fourth streets.

The exterior of the building, as shown in the illustration, is rather severe in treatment, and does not at once give an impression of the enormous proportions on which it is built. This simple fact is in itself a high compliment to the architects, for it is an evidence of a high degree of skill and judgment. The same general statement applies also to the interior. So well are the proportions kept throughout that one does not at first realize the enormous dimensions and seating capacity of the auditorium. Notwithstanding the large dimensions the seating of the house is so arranged that the stage seems near the spectator, and in every case is in perfect view. This is accomplished by bringing the stage forward into the auditorium, so that about a third of it is in front of the proscenium arch. There are two galleries, as shown in the illustration.

On passing from the general entrance on the Sixth avenue side, we first reach a crescent shaped foyer. The general scheme of decoration here is a particularly happy conception, and the illumination has been carried out in an admirable manner. The ceiling is supported by pilasters having elephants' heads worked into the capitals, with the tusts tipped with four-inch round opaline lamps, while three two-inch frosted lamps rest on top of the head, as shown in the cut below.

The illumination in the auditorium is by individual lamps studded in the ceiling. This method of lighting is one which requires especial care and judgment in order to obtain successful results. In this particular case it has been worked out with consummate skill. The general form of the ceiling is that of a dome supported at four points, the four sides being cut off on a line with these points of support, forming arches of large curvature. In the center of this dome there is a "sunburst" containing 400 thirty-two candle-power lamps and 600 sixteen candle-power lamps with Holophane reflectors. Surrounding this central portion of the dome there is a circle of lamps, while another circle is inscribed within the square formed by the supports. Radiating from the smaller to the larger circle there are twelve lines of lamps marking the segments of the dome. The thousand lamps used in this are 8 candle-power. Alternate red and white lamps are studded directly on to the arches between the supports, and another row is placed on the outer faces of the arches. It is this outer row of lamps that is used for the general illumination during the larger part of the performance. These lamps being placed back of the archways, are shielded from the direct vision of the spectators throughout the larger part of the auditorium. This arrangement is highly satisfactory, since it avoids the eye-weariness that results where even a few lamps are within the range of vision for a considerable length of time. When the entire installation on the ceiling is lighted the effect in the theater is exceedingly brilliant.

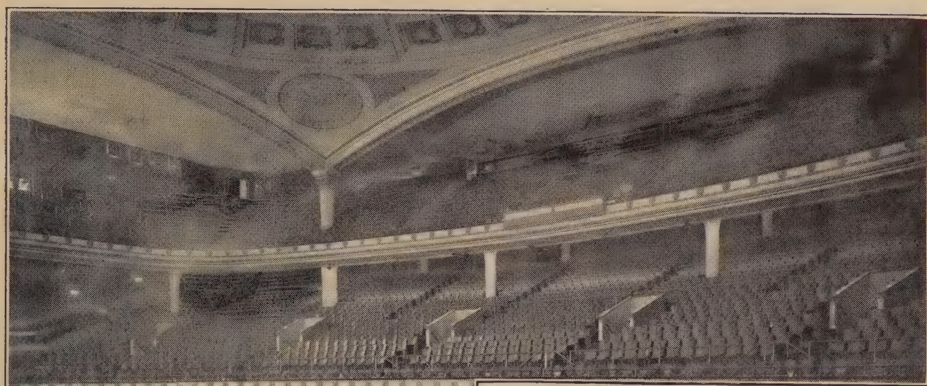
Around the proscenium arch on the auditorium side there is a border containing 600 sixteen candle-power lamps. These are supplied by the service mains from the United Electric Company, and are so connected that should the main service supplied by the New York Edison Company be interrupted, these emergency lamps will be switched on, and furnish sufficient illumination to enable the audience to leave the theater easily if necessary.

The entire illumination of the body of the theater is from the ceiling lights, there being no lights around the fronts of the galleries nor on the side walls, with the exception of signal lights indicating exits. The equivalent of 12,000 sixteen candle-power lamps are used in this manner.

Some illuminating engineers may be inclined to criticize the placing of so many bare lamps on the ceiling; but let it be remembered that this ceiling is unusually high and inaccessible, and that frosting lamps decreases their useful life from 25 per cent. to 40 per cent. The renewing of lamps in this case is an item of most serious importance. Since lamps in the central dome only need to be lighted for short intervals during the intermissions, no

serious inconvenience from the bare filament is felt; while the greater intrinsic brilliancy of the bare lamps undoubtedly adds to the gorgeousness of the general scheme of illumination.

For the minor illumination of passageways, etc., cluster fixtures are used, about 600 lamps being used throughout the building in this manner.



ELMER S. DUNDY.

Taken as a whole, the general illumination of the theater has been provided for in an admirable manner, producing a thoroughly satisfactory visual effect, and conforming to the general air of simple and well-proportioned lines upon which the entire building is constructed. There are few modern buildings in which the illumination can be so unreservedly commended.

Although stage lighting is a special art with which the ordinary illuminating engineer may never have occasion to deal, and with which he would ordinarily, as a matter of fact, be incompetent to deal, it is nevertheless a matter of general interest.

The problem of lighting a stage involves two main propositions: first, light must fall upon the stage from all directions,—front, rear, the two sides, above, and below; second, all of the light-sources must be practically hidden. Besides this general illumination, special objects on the stage require special illumination, and electric lamps may be used as parts of the visible decorative effect.

The general illumination of the Hippodrome stage is provided for in the following manner: Back of the flies

and near their lower edge are placed rows of incandescent lamps set in troughs painted white on the inside. There are 3,700 thirty-two candle-power lamps thus placed. These are arranged on four circuits, part of the lamps being colored. In front of the stage in the usual position, are 600 thirty-two candle-power lamps used as foot-lights. These are divided into green, blue, and white. Just back of the proscenium arch are placed 170 thirty-two candle-power lamps, and immediately above 160 reflector lamps of 50 candle-power rating.

The strongest illumination for ordinary stage work is required to be from the front; to furnish this 25 projecting arc lamps, each consuming from 25 to 50 amperes, are placed in the front of the upper gallery. Over the boxes on each side there are six projecting arc lamps of 25 to 50 amperes' capacity, and on a special bridge at each side of the proscenium arch are similar batteries of 8 lamps each. On a swinging bridge above the proscenium arch there is another battery of eight 50 ampere projecting arcs, and 8 smaller arc lamps above the center of the stage. Back of the proscenium arch at the sides there are bridges with twelve 50 ampere lamps each, and over the switch-board, at about twice the height of these bridges, is another battery of twelve 50 ampere projecting lamps. In the ceiling of the theater immediately above each corner of the stage there are openings, above which are placed 75 ampere projecting lamps which throw their light directly down on the front of the stage.

To prevent shadows from this light directed from the front, incandescent lamps are placed in troughs containing 12 lights each, back of the set pieces at the rear of the stage, there being 125 of these troughs used. There are also 10 fixed troughs containing 12 thirty-two candle-power lamps each. Besides these, nine 50 ampere arcs are used as portables on the floor at the rear of the stage.

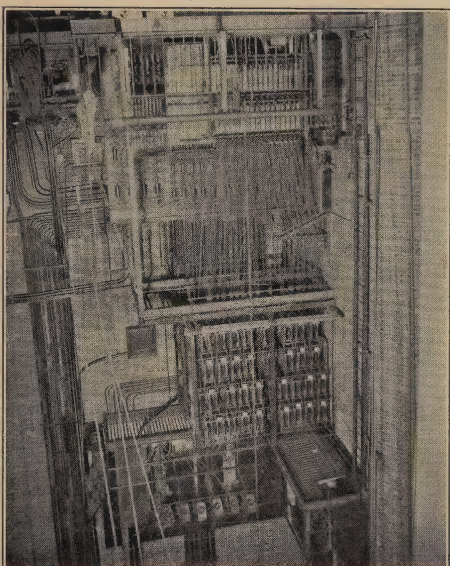
Besides the lamps regularly installed, there are used in addition, in the "Court of the Golden Fountains" 1,700 eight candle-power lamps attached to the scenery in the back ground, and 1,800 lamps varying from 4 to 32 candle-power on the scenery in the foreground. The wiring connections for all of these special lamps must be strictly in accordance with the regulations of the Fire Underwriters and the city authorities, and must be so arranged as to be quickly put in place and removed. The connections are all with flexible cord; circuits coming in contact with water are through cable enclosed in a special rubber hose, The connections are made by plugs in the floor of the stage; and so carefully have all the details been worked out that the entire electrical connections for the setting of this scene can be made in one minute.

The incandescent lamps used in the stage lighting are equivalent to 12,000 sixteen candle-power lamps. The projecting arc lamps, of which there are 112 altogether, undoubtedly are equivalent in total light producing power to at least five times as many enclosed arc lamps with clear globes, thus equaling 560 ordinary arc lamps.

All of this vast array of lamps must furthermore be so connected as to be operated from a single switch-board, and in the case of a majority of the incandescent lamps, connected with resistances, or "dimmers," by which their candle-power can be reduced. The switchboard and dimmers are placed on bridges at one side of the stage, a view of which is shown in the illustration. The switching of all of this enormous quantity of current is done by the ordinary push button flush switch, such as is used in dwelling houses for lighting up the ordinary chandelier. These switches operate on the relay principle, making electrical connections which operate the main switches. The dimmers are shown above the switchboard, and are connected by cords to the levers on the switchboard by which they are operated.

If these figures as to the number of lamps and quantity of light used seem

exaggerations, a contemplation of the actual size of the building, and particularly of the stage, will help to form a just conception of the requirements. There are two or three theaters in New York City, running standard high-class attractions, either of which could be placed on the stage of the Hippodrome without perceptibly interfering with the regular performance; and a majority of theaters could be placed upon the stage and still leave a considerable amount of room. The curtain at the rear of the stage is 185 feet long and 65 feet high.



SWITCHBOARD AND "DIMMERS."

While electric light is used without stint in the production of the marvelous scenic effects on the stage, it has also been used with equal lavishness on the exterior to proclaim to the wayfarer the attractions within. At each of the Sixth avenue corners there is a skeleton ball outlined with lamps, lamps being used also for various other outlines, as shown in the illustration, 3,000 lamps in all being used for this purpose, ranging from 4 to 32-candle-power, mostly 16. The three signs on the front, or Sixth avenue face, reading "Hippodrome" have letters four feet high. The vertical signs on the corners are virtually double signs facing two ways at right angles. These permanent signs use 800 lamps, while the central sign uses about the same number.

To supply the current for the lighting three service mains enter the building, two from the New York Edison Company, and one from the United Electric Light & Power Company. The main service from the Edison Company has a capacity of 10,000 amperes, and the smaller service main from the same company, of 3,000 amperes. The emergency service main from the United Electric Light & Power Company has a capacity of 3,000 amperes. In the last act of the present performance, practically the entire capacity, except the emergency, is used. There are over 4,000 central station in the United States; the maximum output of a majority of these stations is less than the amount of current used on the Hippodrome stage.

The present installation of stage lighting, together with the marvelous scenic effects that are produced by special lighting, are all due to the present Chief Electrician, Mr. Charles DeSoria. On account of his slight stature and youthful appearance, Mr. DeSoria might well be mistaken for a particularly alert and intelligent messenger boy. The magnificence of the work he has accomplished seems all the more wonderful when it is learned that he has never enjoyed the advantages of a technical education, but has "picked up" the whole matter from his own study and ingenuity in his leisure time. He has literally grown up in the theater, having been assistant treasurer, counting up receipts and expenditures with managers before he had achieved the dignity of long trousers. His one simple rule, which has invariably led to success in his various capacities, has been: "the way to do a thing is to go at it and do it." Higher mathematics, intricate physical laws and theories he leaves to those who do their work on paper; but for producing actual results he depends upon judgment and common sense,

FREDERICK THOMPSON.

By Courtesy of the *American Architect*.

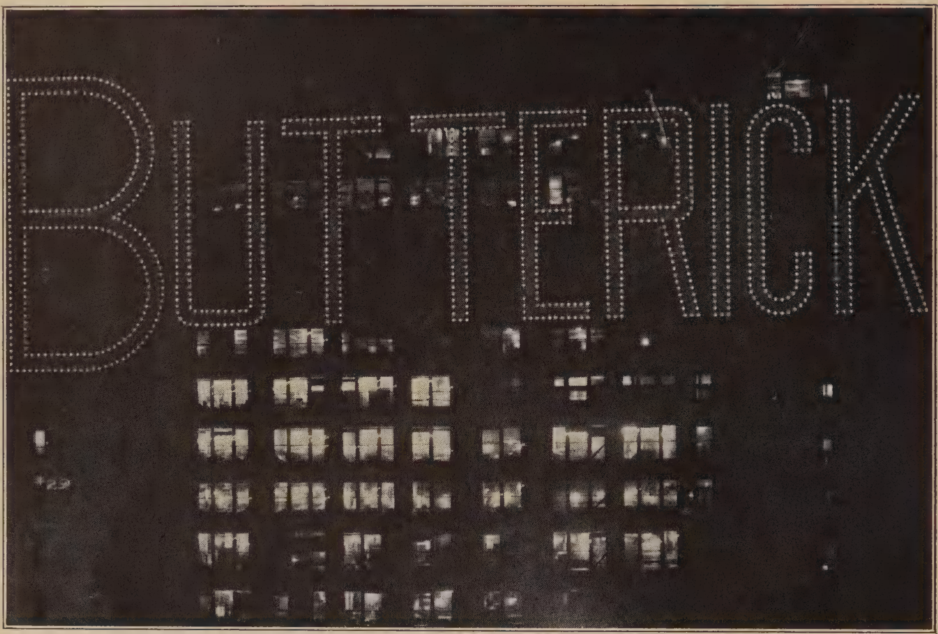
backed by intelligent observation; and on this basis he has "made good" in every instance. In his youthfulness and previous inexperience in this particular line he is a fit companion for Messrs. Thompson and Dundy, the originators and managers of the enterprise.

By Courtesy of the New York Edison Co.

In conclusion, a single thought may be added for the cogitation of the illuminating engineer:

Without the electric light what would the Hippodrome be?

CHARLES DE SORIA.



The Largest Electrically Illuminated Sign in the World

By Paul H. Jaehnig.

Oft times in illuminating engineering, there are problems that present themselves, which are difficult to solve satisfactorily, and which raise a doubt in the mind of the engineer as to the ultimate outcome of his plans. While the natural laws of light and illumination are thoroughly understood and can be readily applied in most cases, yet a case may arise where the application of these laws give the engineer little or no idea as to whether his solution of the problem will give the result he seeks to attain. In other words, there are certain problems in illumination which can be successfully solved only by experiment.

Such cases may arise where the problem is of such magnitude, or is so out of the ordinary, that there is no data available to guide the engineer in working out his plans.

It was just such a problem that confronted the engineer when he was commissioned to prepare plans for the illumination of the mammoth sign on the side of the building of the Butterick Publishing Company, Ltd., facing the North River and located at Spring, Van Dam and McDougal streets, New York City.

When the illuminating engineer first took hold of the problem, he was confronted with the following conditions: The building is seventeen stories high, painted a light buff, and near the top is a sign 225 feet long, painted in black letters reading BUTTERICK, the letter B being 68 feet high, while the balance of the letters are 50 feet high, with members 5 feet wide for all letters, except the B, which has members 6 feet wide. It will be noticed, by referring to the cut Fig. 1, that the

letters at the end of the sign are crowded closer together than those at the beginning. The reason for this is, that when the sign was painted on the building, the blank wall spaces between the windows had to be used as far as possible for a background for the upright members of the letters. It must be borne in mind that the wall does not present an unbroken surface for the sign, but is literally honeycombed with windows, and in addition to this, there is a large fire escape that crosses the middle of the sign.

The experiments conducted in connection with this sign to determine the best method of illuminating it, showed some very interesting results, besides presenting other problems which remained to be solved.

It must be borne in mind, that, when the order was given to illuminate this sign, the Butterick Publishing Company did not wish a brilliant sign, that is, one that would illuminate part of the water front as well as the building, but, instead, desired a clean cut, clear outline of each letter, so that the sign would be legible as far as it could be seen.

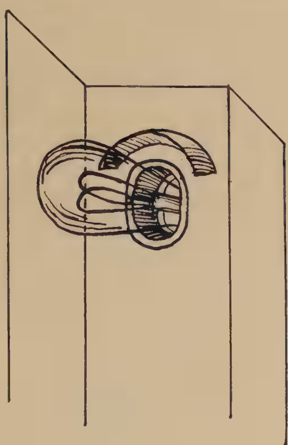


FIG. 1.

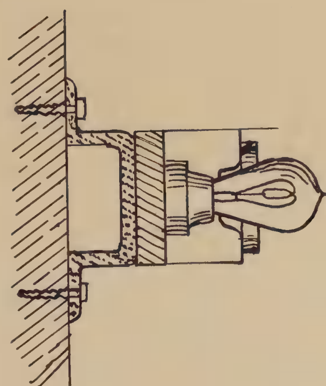


FIG. 2.

Having this data at hand, and bearing in mind the magnitude of the undertaking, together with the very important fact that we have a black letter on a light background, the problem of how to properly illuminate the sign becomes a serious one, in the solution of which, the engineer has no data to guide him. How then, is the engineer to meet the situation, how is he to formulate his plans with no available data? He must simply make his own data to suit the case in hand, in other words, he must experiment, as this is the only way he can determine definately how to prepare his plans and be assured of ultimate success. It was by experiment that data was obtained, from which, the final plans for illuminating this sign were worked out.

Referring to the experiments conducted, the first question to be determined was the spacing of the lamps, and, incidental to this, the question of the candle-power of the lamps. In carrying out the experiment, strips of lamps were prepared consisting of porcelain receptacles mounted on a wood strip four inches wide, and made in lengths of 50 feet. There were six sets of these strips provided with lamps, spaced 6 inches, 12 inches, 18 inches and 24 inches apart. In addition to this, there were provided lamps of four, eight and sixteen candle-power, both clear and frosted. The vertical members of certain letters were then selected, and on the face of

these members, all the strips of lights provided were installed, with lamps of different candle-power half being clear and half frosted. The first selection of lamps with respect to spacing, resulted in placing the higher candle-power lamps in the strips with greater distance between the lamps, while the lower candle-power lamps were put in the strips with the smaller spacing.

After the strips were all in place and burning, a trip was taken on a P. R. R. ferry boat running to 23d street, so that the result might be viewed from different points along the water front. The result of this first experiment was not entirely satisfactory, inasmuch as the right combination of spacing and candle-power was not hit upon at this time. In addition to this, another very serious problem presented itself. It will be remembered that the last few letters of the sign are crowded close together, and that the sign itself consists of black letters painted on a light background.

The experiment brought out the fact, that, because of the combination of black letter and light background, coupled with the fact of the letters being crowded close together, there was a tendency to run together, as it were, that is, the light from the strips in adjacent letters would blend, thus destroying that clear sharp outline of each letter, so much desired.

The second experiment was conducted along the same lines, and in this experiment was determined exactly which combination of spacing and candle-power would give the best result, that is, a four candle-power lamp spaced 18 inches apart. This was the combination that was finally used throughout the sign.

The other important fact that this experiment determined was, how to preserve the clear sharp outline for each letter. This was accomplished in the following manner:

The members of each letter being five feet wide, the illuminating strip was placed one foot from the edge of the letter all around, making the two strips forming the outline of the letters three feet apart. On the outer edge of the strip, that is, the side away from the center of the member, a light shield or band was arranged so as to cut off all light from the lamps on one side of the strip. This shield was arranged so that its upper edge was even with the top of the lamp filament, thus cutting off the direct rays on the light background, and preserving the clear outline of the letter. The shield is so designed that it does not obscure the lamps, even though the sign is viewed at a very acute angle. This arrangement tends to confine all the light to the body of the letter, and allows none to fall directly in the background. This arrangement is clearly shown in Fig. 2, which is a cross section of the light strip on the sign at present. Having now sufficient data to assure one of the definite results, we are ready for a practical application of this data, in other words, we are ready to build the sign. This in itself is a stupendous undertaking, when one stops to think of the size of the sign, which is in fact, the largest electric sign in the world.

As was stated above, the sign was painted on the wall long before the question of illumination came up, and it was up to the builder to make a sign to fit the one on the building; in other words, he must make his work conform absolutely to each individual letter in the painted sign. In carrying out the practical construction and erection of the sign, required considerable engineering ability and experience in sign construction, inasmuch as there seemed to be a continual series of problems constantly arising which had to be solved, and on the correct solution of which depended, in a great measure, the success of the whole undertaking.

In carrying out the practical work, the first thing to be done was to have a large photograph of the side of the building, made from a nearby roof, showing the painted sign and its relation to windows, fire escapes, etc. This photograph was then accurately scaled by means of measurements taken at

the building. From this photograph a scaled plan was drawn, and this plan, in conjunction with measurements taken of each individual letter, formed the basis of the actual construction work. Each letter was then carefully laid out full size on the floor of the shop, from which the actual sizes and shapes of the various strips forming the letters were made.

The construction of this strip work is best understood by referring to Fig. 2. It will be noted that the back of the strip work is made from thoroughly seasoned pine lumber ⅞ inches thick and four inches wide. After the lumber was cut to the required size and shape, it was thoroughly saturated with a waterproof compound by immersing it in a tank, and both sides were covered with heavy sheet steel, to make it fireproof, and this was also waterproofed. The lamp receptacles were fastened to this strip at regular intervals. For the protection of these receptacles, a galvanized iron channel was provided, arranged to fit over the edges of the strip and fastened to it with brass screws. This strip was provided with the required openings for the lamps, corresponding to the receptacles as shown in Fig. 3. These openings were made large enough to accommodate a rain cup, a very simple and ingenious device designed to keep the rain and snow from entering the strip work, and thus destroying the vital parts of the work. This "rain cup" is a cone shaped metal cup or shell with a flanged opening at one end about two inches in diameter, which fits the opening in the strip work and is securely soldered to it, and an opening at the other end about 1⅛ inches in diameter, which just allows the neck of the lamp to pass through. This can be better understood by referring to Fig. 2. In addition to the rain cup, another simple device was employed to keep the rain out of the strip, which might be called a rain shedder. This device was similar to a rain cup cut in half on a line at right angles to the plane of the openings in the cup. These rain shedders were soldered to the outside or face of the strip work just above the lamp openings, and tended to divert the rain, that might be washing down the face of the strip, away from the lamp openings.

After the metal work for the strips was completed, it was painted both inside and outside with one coat of red lead and two coats of dead black water-proof paint, to protect it from the action of the elements, and also to make it invisible in the day time, so as not to detract from the appearance of the sign by day.

While the strip work for each individual letter was laid out on the floor of the shop, yet it was necessary to make the strips in sections or convenient lengths to enable it to be transported, handled and erected. This required considerable engineering to make sure that all parts would fit when they were ready to be erected on the wall.

All the work of erecting the strips had to be done from a swinging scaffold, and this was not the most secure place to attempt to make any alteration if the parts did not fit.

The question of securely fastening the strips to the wall next presented itself. This was solved in the following manner: A cast-iron chair 1¼ inches wide was provided with a bolt hole in each end, and this chair was fastened to the brick wall at regular intervals by means of expansion bolts. This chair answered a two-fold purpose, first, it supported the strip work about 2½ inches away from the wall, thus preventing any rusting of the sheet metal in the strip work, which would be the case were it tight against the wall, and, second, it provided means for concealing and supporting the circuit wires leading to the various parts of the letters. Fastened to the back of the various sections of the strips were flat iron tongues, or clamps, with an offset equal to the thickness of the chair, and these tongues or clamps were spaced to match the chairs exactly. The strips were then hung on the chairs and

when the clamps were finally tightened, the strips were absolutely rigid, in other words, they were there to stay.

The wiring of the sign will next claim our attention. Near the center of the roof in the tank house, a heavy feeder terminates, coming direct from the main switchboard in the basement. From this point, three three-wire subfeeds were run with lead covered cable in iron conduit, across the roof to three distributing panel boards. These panels are of the regular type provided with plug fuses for the branch circuits, and each has a main switch. They are enclosed in heavy sheet steel boxes made water-proof and are mounted on the parapet wall directly above the sign, one near the middle and one near each end. From these panels, the branch circuit wires are carried to the various portions of the individual letters. This portion of the wiring is done with lead covered duplex wire. Where the leaded wire runs in the back of the strips, it is securely fastened to the chairs above mentioned, and where it leads to the panel board, it is served with marline and supported by large porcelain clamps.

The construction throughout, both in the sign itself and in the erection and wiring, is the very best obtainable and represents the highest development of the art along these lines, as no time or expense has been spared to make the entire installation a lasting one, one that will stand the test of time.

These, then, were the problems that confronted the engineer when he was commissioned to build the sign, and how well he has met and solved them, we leave to the reader's own judgment, remembering the monument to his skill still stands and will continue to stand for years to come.

The Butterick sign as it stands today, contains exactly 1,134 4 candle-power 5 watt per candle-power lamps, which gives a total current consumption of 22.68 kw. per hour, which, at a rate of five cents per kw. hour, brings the cost up to $1.134 per hour.

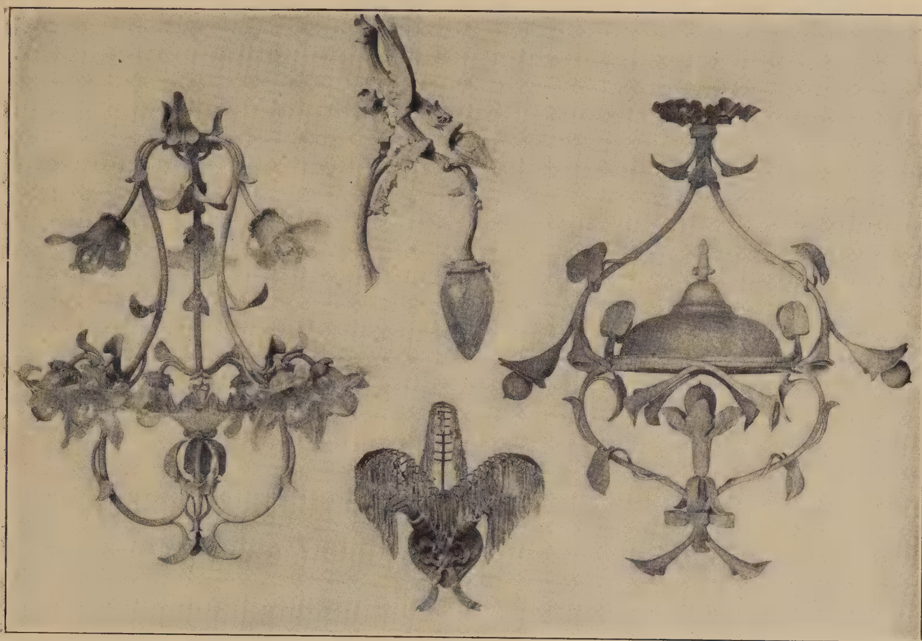
The advertising value of the sign, because of its very conspicuous location, can hardly be estimated, and when the low cost of operation is considered in connection with the results obtained, it is very evident that it is a paying venture for the owners.

In the construction of this sign, there were used over 1,700 feet of the strip work, over 500 cast-iron chairs, requiring over 1,000 expansion bolts and necessitating over 1,000 holes to be drilled into the brick wall to hold the chairs in place.

The sign is divided into 60 branch circuits, requiring over 4,000 feet of leaded duplex wire to run from the panel board to the various parts of the sign.

In order to replace burned out lamps, a boatswain chair was provided, operated with a tackle and fastened to a portable boom on the roof. With two men operating this device, lamp renewals are quickly made, as it is a simple operation.

Aside from the illuminating engineering, the mechanical, as well as the electrical features of the installation were so well planned and carried out as to command more than passing notice. Taken all together, it is a wonderful piece of work, and the more one considers the many details that had to be thought out, and the many difficulties to be surmounted, the more one wonders how it was all so successfully executed.

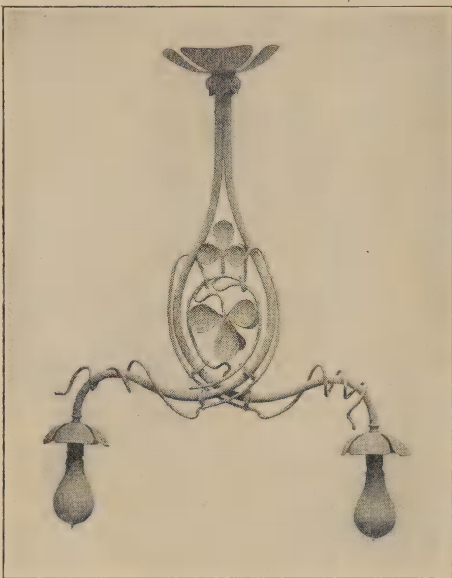


DESIGNS BY HENRY THIEBAULT & SONS, PARIS.

"Art Nouveau" in Fixture Design

It has often been said, and with much truth, that the design and construction of fixtures has not kept pace with progress in the production of light, and more especially has failed to take advantage of the wide field of possibilities presented by the advent of the electric lamp. When illuminating gas becomes a commercial illuminant, the chandelier (i. e. candle support) was changed only by making the arms hollow in order to permit the passage of gas; and when finally the electric lamp supplanted the gas flame, the designer merely put wires through the gas pipes and attached an electric lamp in place of the gas burner. And so, even up to the present time, there has been no considerable divergence from the forms of construction and design that were in use before illuminating gas was known and candles afforded the highest type of light production. Art critics have also had equal occasion to accuse the architect of a like sterility of invention, and a tendency to merely recombine and rehash the principles that were perfected by the ancient builders.

Efforts to break away from these traditional forms and to create something absolutely new in its fundamental motif should therefore always be encouraged, to the end that some permanent addition to art may eventually result. The fact that most such attempts in the past have been fruitless of permanent results is not sufficient excuse for ceasing further efforts. "Art Nouveau" (new art) is a term which has become familiar to many as designating a particular form of applied art, used mostly in house decoration. In Europe, where the idea originated, it has been taken up quite generally by the designer of lighting fixtures. The fundamental motif of this school of art appears to be a use of the graceful curves found in vegetation, particularly that of tropical and



CHANDELIER, BY CHAS. BLANC, PARIS.

equatic origin, and a more or less faithful adherence to nature in the use of these curves rather than their reduction to conventional forms. This principle lends itself particularly well to the design of fixtures for the support of electric lamps, which seem to naturally fit into designs simulating fruit and flowers. The possible variations on this theme are limited only by the difference of floral structures.

A sharp distinction should be drawn in applied art between simulation and imitation. Metal of any kind worked into the various shapes and forms of fruits, flowers, or leaves, is pleasing in itself, while at the same time affording unlimited opportunities for skill in workmanship, which always lends an additional charm to applied art. In this case there is no intention, real or applied, of deceiving the beholder; no one will mistake a metal leaf for a real one. Such a construction is therefore simulation, and not imitation; for imitation may be properly defined as copying with intent to deceive. An opal glass tube, formed in

CHANDELIER, BY CHAS. BLANC, PARIS.

CHANDELIER, BY CHAS. BLANC, PARIS.

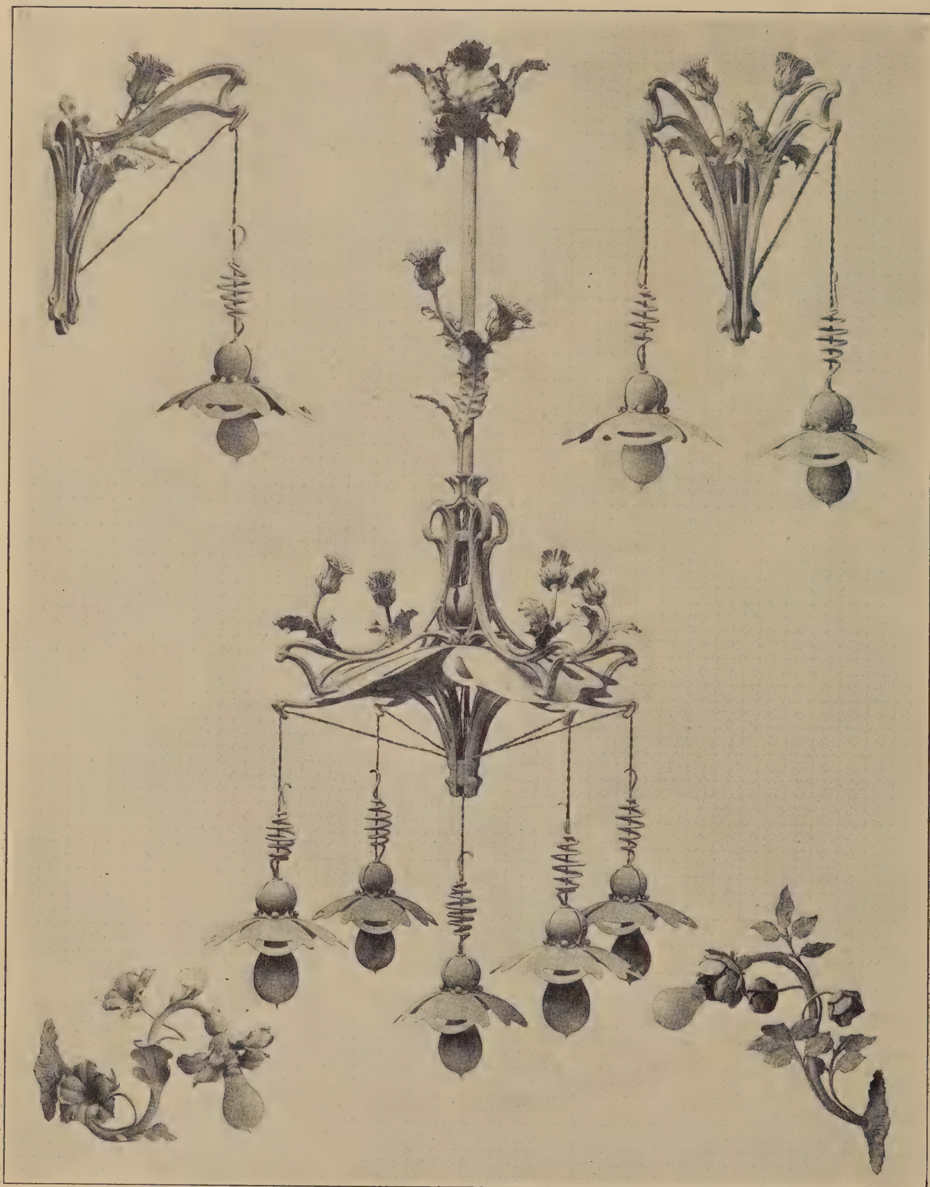
the exact shape of a candle, and placed in a candle-holder with saucer underneath, is an imitation; for while it may not actually deceive any one, its manifest purpose is to give the impression of a real candle burning. A deception or a lie can never be the foundation of true art.

In the simulation of the various forms found in nature glass may also be used with equal effect with the metals. Shades wrought into the form of the calix and corolla of a flower

DESIGNS BY HENRI THIEBAULT & SONS, PARIS.

are welcome relief from the conventional etched or sand-blasted globe that has been worked out with unending monotony for centuries past.

Art Nouveau fixtures have not thus far received much recognition from the American manufacturer; which fact, however, does not necessarily condemn them as inartistic. Undoubtedly they require a high degree of artistic taste in their design, and an equally high degree of mechanical excellence in their construction; and we may as well frankly admit that both of these requisites are far more difficult to obtain in America than in



SIDE BRACKETS AND CHANDELIER, BY CHARLES BLANC, PARIS.

Europe. Still, if it shall prove that this form of applied art has in fact struck a new artistic principle, founded on the fundamental laws of esthetics, it is bound to make its way, even among the Philistines. It is at least worthy of the serious attention and study of the American designer who is willing to look beyond the conventional and often meaningless forms that have circumscribed his field of vision for the past centuries, and is seeking for new fields of artistic expression.

THE ILLUMINATING ENGINEER

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THE DISCUSSION OF PAPERS READ BEFORE THE ILLUMINATING ENGINEERING SOCIETY

Even the most enthusiastic illuminating engineer must admit that the science and art of illumination in its present state is far from being thoroughly established on accepted principles. It was one of the chief objects of the promoters of the society to bring together those interested in the subject for the purpose of discussion and exchange of views; and without reflecting at all upon the value of the papers in themselves, it is quite likely that the discussions of the papers will form, at least for some time to come, the more valuable part of the proceedings. It is to be hoped, therefore, that the fullest opportunity for such discussion will be provided. While subjects for papers are plentiful, and are likely to remain so, the temptation to use a large portion of the time for their presentation, with a consequent curtailing of the time for discussion, should be carefully held in check.

"Who shall decide where doctors disagree?" Very often the layman, who, unhampered by preconceived ideas, and seeking only practical results, is in a position to give a decision of more value than that based upon the theories of the "doctors."

The discussions of the papers, as reported in this issue, left a number of points undecided and several questionable statements unchallenged. Believing that a further discussion and exposition of these papers, as well as of the papers that may hereafter be presented, would be of value, we cordially invite anyone interested to continue the discussion in the pages of THE ILLUMINATING ENGINEER. We do this in the belief that valuable points may be brought out on mature consideration of the papers, that would not occur at the time of reading, and furthermore, that a written argument is more likely to be confined to the actual and vital points under consideration than an impromptu oral discussion.

THE INVERTED INCANDESCENT GAS BURNER

From the paper and discussion on this subject presented at the last meeting of the Illuminating Engineering Society it is evident that the future of this latest comer in the field of gas lighting is not yet absolutely assured. The word "inverted" as applied to this class of burners, and accepted by the makers, is an admission in itself that the natural order of things has been reversed; in other words, that the burner in fact is "upside down," as we suggested in our last issue. The natural course of a flame is upward, and the natural position of the combustible is underneath the flame. Both of these conditions must be reversed in the inverted gas burner. It is not surprising, therefore, as Mr. Rettich so clearly pointed out in his paper, that many difficulties should have been encountered in the attempts to reverse this order of nature. It does not necessarily follow, however, that these obstacles may not be overcome to such a degree as to make a burner of this description practical; and the testimony of those interested in the production of burners is emphatically on the affirmative side of the argument. The attempt is undeniably in the right direction on general principles; that is,

it aims toward a more sightly construction of burner and lamp, and to a more economical distribution of the light. On account of the higher intensity of the mantle also a greater necessity for diffusion by some sort of a globe is apparent; both of which tendencies are toward better illuminating practices.

The most vital question of all, however, was not brought out either in the paper or the discussion, namely, the relative efficiencies as light-producers of the inverted and upright burners. By efficiency as a light producer we mean the ratio of the total or mean spherical candle-power to the gas consumed. It has been claimed that the inverted burner gives a higher efficiency on account of the pre-heating of the gases by their own combustion; but some figures from careful tests on this subject would be highly instructive. If this claim can be substantiated it will be a very strong argument in favor of the inverted burner. On the other hand, if there is any considerable diminution of efficiency by reason of this method of construction, it seems hardly likely that this form of burner can ever hold but a subordinate place in gas lighting.

On this question of efficiency the results obtained in the series of tests by Dr. Drechschmidt, of Berlin, Germany, are highly instructive. Dr. Drechschmidt's paper will be found reprinted in full in another part of this issue. From these tests it would appear that the inverted burner has decidedly the best of the argument as to efficiency, although the results are somewhat obscured by considerations of lower hemispherical intensity rather than mean spherical. Where lower hemispherical intensity is dealt with the only fair means of comparison with upright burners, is when they are fitted with the most efficient reflectors that can be used. If the indications of these tests prove to be true, and the total efficiency of the inverted burner be found in practice to exceed that of the upright burner, then its fight for supremacy may be considered won; for the incidental difficulties involved are morally sure to be overcome by the skill at the command of the various manufacturing companies.

As the inverted burner unquestionably had its origin in a desire to compete with the electric lamp, both in appearance and distribution, it is interesting to note that a very successful imitation of the electric lamp used in an upright position, is on the market. The small Welsbach burners thus made with a base like a lamp socket and with a chimney in the shape of a tubular lamp, or an imitation candle, are exceedingly clever in construction and ornamental in appearance, and will undoubtedly make a place for themselves in dwelling house illumination.

"ILLUMINATING ENGINEERING FROM THE ARCHITECT'S STANDPOINT"

The paper on the above title, which was presented at the last meeting of the Illuminating Engineering Society by Mr. Waldo S. Kellogg, who is associated with the architectural firm of Carrere & Hastings, of New York, contains a number of points which the illuminating engineer should carefully ponder. It has been the universal complaint of those who have attempted to handle illumination on strictly engineering principles that, they have to combat the prejudices of architects. While there is undoubtedly a considerable degree of justice in this complaint, it should be remembered that the illuminating engineer may also have his prejudices.

Efficiency is not the sole aim and end of illumination, and the illuminating engineer who would be successful must not only be a student of art as applied in architecture and structural decoration, but must have a degree of natural taste and skill in this direction. In a science that is professedly not exact, there are ample opportunities for producing the desired results without going counter to the individual tastes and preferences of the architect and decorator. The Il-

luminating Engineering Society can do much toward removing these architectural prejudices, and also in fostering in the illuminating engineer a respect and appreciation for the artistic methods which have so large an influence with the architect.

Mr. Kellogg refers to the lack of uniformity in methods of rating commercial light-sources, and makes some very just strictures on this common evil, which seems to be growing rather than diminishing. The evident incongruity of rating incandescent lamps by their horizontal intensity alone has often been pointed out; but so long as the general public remained in ignorance of the simplest principles of illumination, no sufficiently powerful influence arose to change this method. The spread of knowledge among consumers, however, has taken a sudden impetus, and manufacturers are now showing a tendency to fall back on the still less logical method, of rating a lamp by its watts. As this is a new term to the public, and therefore entirely meaningless, the rating of a lamp by this method can have no other effect than to keep this important element of illuminating engineering in the fog. In some cases even the intensity of light in a certain direction produced largely by reflection, is given by intimation as the "candle-power" of the light.

Mr. Kellogg's warning against the tendency that has been prevalent ever since electricity became used for lighting purposes, to increase intrinsic brilliancy as well as the total flux of light, is also very timely, and should be heeded by both the manufacturer and the illuminating engineer.

AN IMPORTANT DECISION RELATIVE TO DESIGN PATENTS

It may be truthfully said that there is no trade or profession which is not interested in some phase of the patent law. The mechanic and artisan is interested in mechanical patents; decorative artists and designers, in design patents, and the literary and professional man in copyright, which is a species of patent right. It is probable that no single provision in the fundamental laws of the country has had a greater influence on its development than the patent laws; and yet there is no department of the general government which receives so scanty attention. The reason for this neglect is exceedingly simple and apparent. It is simply due to the fact that the patent office cannot be turned to political advantage in any way. Politicians may be said to be the only individuals in the country that have no use for it; and as the majority of legislators must always be classed as politicians, the cause of its neglect may readily be appreciated.

It occurred to the present Commissioner of Patents that the design patent law, which had been in operation since 1836, was defective, and at his request the old law was wiped off and a new one of his framing put in its place by Congress. This change was made with no more general stir or discussion than would arise from the introduction of a private pension bill. In carrying out this law, the Commissioner made a ruling which still further changed the practice of design patents. Probably no other officer in this or any other similar government is invested with such peculiar powers as is the Commissioner of Patents. His powers are both legislative, judicial, and executive. They are legislative in that the rulings that he lays down concerning patent law practice are in fact laws until they have been passed upon by a higher court; he is judicial in that he decides what may and what may not be granted patent protection, subject to review by a higher court. At the same time he is an executive officer in charge of the general business of the department.

Acting in his capacity as legislator, the Commissioner prescribed the exact form in which a design patent application should be taken out, which eliminated all worded description, the only form of claim allowed being, "a design as shown in the illustrations." This would have been less objection-

able if the regulations as to drawings were modernized. All drawings are required to be in pen and ink, and to properly show by this means the designs which are patentable would require the skill of an artist of the highest qualifications. This provision as to drawings was made years ago before the modern half-tone processes had been developed. In the present high state of these processes, and in view of its cheapness, the provision as to drawings should be entirely revised, and a photograph of the design, instead of being prohibited as now, should be required, for in no other method can the design be so clearly shown, and oftentimes the design cannot be shown by any other method of illustration.

In refusing the privilege of describing a design, the Commissioner undoubtedly had in view the simplifying of the application, and possibly the prevention of mechanical claims from creeping into design patents, which could not be obtained strictly under the mechanical patent law. There are, however, many cases in which it is practically impossible to show, especially by the kind of drawings now required, the appearance of the "design claimed." This is particularly true of designs on glass. Owing to its transparency, the configuration on both sides enters into the general effect as seen, and it is practically impossible to picture the effect of transparency. This fact was recently brought to the attention of the Court of Appeals on an appeal from the ruling of the Commissioner of Patents, in which Judge Deuel, ruled that "a description is not only proper, but necessary, and the claim should carry a description of the salient features of the design."

THE CO-OPERATIVE ELECTRICAL DEVELOPMENT ASSOCIATION

The above title is that of a new organization whose purpose is well expressed in the phrase which has been adopted as the slogan of the Society: "All Together All the Time for Everything Electrical." The ultimate object is to induce the public generally to make a larger use of electricity in all its forms.

While this purpose is professedly purely commercial, aiming towards increasing the sale of apparatus and material required for the production and distribution of electricity, in its ultimate effect it stands for results which have a far wider and deeper significance than the mere increasing of profits and dividends.

The use of electricity in every instance is an evidence of progress.

An enlarged use of electricity means greater comfort, more of the refinements and pleasures of life, and less of that part of toil which is irksome and brutalizing. Whether it be in the freedom from smoke and cinders afforded by electric traction, or the briliancy and comfort of the electric light, or personal communication by telephone, or the uniting of nations by the wireless telegraph, or the electric heating of a chafing dish—electricity in every case is synonymous with better conditions for society and the individual: whatever agency therefore will increase its use is a real benefit to mankind.

The entire work of the Association is accurately and briefly summed up by the well-known phrase, "A Campaign of Education." The majority of mankind are conservative and are much influenced by precedent and usage. The advancement brought about by the adoption of improvements and inventions is of a slow growth unless cultivated and stimulated by external influences; and the most potent influence of this kind is that which is generally looked upon with disdain by the theoretical philanthropist,—that expressed by the term "commercialism."

The Co-operative Electrical Development Association should, therefore, receive the heartiest support, not only of those financially interested, but of every one who has at heart the general advancement of civilization. The present headquarters of the Association are at Cleveland, O.

The Illuminating Engineering Society

Papers and Discussions Presented at the Regular Meeting, Held in the Edison Auditorium, New York, March 13th

THE LUMINOUS ARC ELECTRIC LAMP

By E. L. Elliott

The discovery of the electric arc was made a little more than a century ago by Sir Humphrey Davey, who produced it by means of current generated by the thousand cell primary battery of the Royal Institution in England. The utilization of this discovery as a source of illumination necessarily had to await the discovery of a practical means of producing electric current of sufficient voltage and capacity; and when such means were secured by the perfection of the dynamo generator the arc lamp speedily became a commercial light-source.

Following the means of generating and regulating the current supply there has been a continuous study to improve the immediate source of the light; that is, the electrodes between which the arc is formed. The objects sought have been to decrease the consumption of the electrodes and render them of such uniform texture and composition as to produce a steady light. From the soft charcoal sticks of Davey to the compressed carbon rod of hard gas coke was a long stride toward the desired end. Those coke carbons, with their copper platings to reduce resistance, might facetiously be said to have produced the original flaming arc; for as drops of melted copper ran into the arc and particles of incompletely carbonized matter came in its path the arc would send forth such displays of green and yellow scintillations as would put the modern flaming arc to shame in the matter of fantastic and lurid effects.

The improvement in the quality of the carbon was a question of degree rather than of fundamental principles. The only radical improvement in the arc lamp itself was the discovery of the fact that the consumption of the carbons could be greatly retarded by preventing the free access of air to the arc; or, in common parlance, by enclosing the arc. While this reduced the rate of consumption to less than one-tenth of that under the ordinary conditions, it also developed other features in the arc, notably the ability to maintain an arc at practically twice as great a voltage and a change in the distribution of the light and in its color. It is worth remark in passing that the popularity of the enclosed arc on its first commercial appearance was undoubtedly promoted to a considerable degree by a mild form of "faking." It was discovered by the manufacturer that, by the use of an opalescent enclosing globe, the entire globe became apparently luminous, thus giving the appearance of a large source of comparatively lower intrinsic brilliancy; the lamps were commonly spoken of as "incandescent arcs," although the arc itself had no more luminosity than did the ordinary open arc. "A globe, full of incandescent gas," was an easy prevarication to palm off on the unsophisticated public and served to distract attention from the fact that the lamp was in reality far less efficient than the open arc which it sought to supplant. Unlike most cases of commercial faking, however, the ultimate results were highly beneficial; for it led the public to appreciate the fact that mere efficiency in the production of light is not the only thing to be considered in illumination and that there is such a thing as quality in light as well as in other commodities. The soft, diffused

light from the enclosed arc fitted with two opalescent globes was so manifestly superior to the glaring, unshaded open arc as to require no further argument in its favor. It had the further great advantage of requiring much less attention, a feature which appealed particularly to the American public.

Thus, notwithstanding its inferiority as a light producer, the enclosed arc rapidly supplanted in this country the older form; but as methods of accurately measuring the light of arc lamps became perfected and their results better understood the shortcomings of the enclosed arc in point of efficiency became more generally recognized and this doubtless had some influence on stimulating research in the direction of securing a more efficient means of converting electrical energy into illumination. In the quality of carbons with reference to their ability to withstand disintegration, little more was to be hoped for and experimenters therefore began to look in exactly the opposite direction; that is, to the production of an electrode for the express purpose of its being consumed by the passage of the current.

It is a well-known fact that the efficiency of light production is much greater from incandescent gases than from solids, and likewise that amorphous carbon is one of the most inefficient substances for the production of light radiations. Clearly, therefore, if other substances having higher light-radiating properties or matter in the gaseous state could be used as the radiating source a correspondingly higher efficiency would result. This fact is so obvious that, as might be supposed, researches along this line are comparatively old, much older in fact than is popularly supposed. The idea of introducing substances of higher radiating power than carbon into the electric are was made a subject of a patent by a French inventor as long ago as 1876 and researches in this line are of record in 1844. As researches by various competent experimenters both in this country and in Europe have since been pursued with a considerable degree of assiduity, as the numerous patents show, it seems rather remarkable that commercial results have been so long delayed; in fact it might also be said that the whole matter had to be rediscovered.

Foremost among the rediscoverers should be mentioned Bremer, who, ignorant of the results of previous workers in the field, began in 1898 to work along these lines, and pursued them with indefatigable patience and industry until an actual commercial result was obtained. Without entering into a general discussion of the theory it will be sufficient for our purposes to understand that by the introduction of substances having a higher light-radiating power, such as salts of the calcium group of elements, into the electrodes, the arc itself is rendered highly luminous and becomes the principal source of light in place of the heated end of the positive carbon as in the case of the ordinary arc lamp.

At this point attention for a moment may be called to a slight inconsistency in the use of terms. Arc lamps of this description are popularly called "flaming arcs," since the arc is luminous, like a flame. For the sake of scientific accuracy, however, it would be far better to use the term "luminous arc," since this work exactly describes the conditions and leaves the work "flame" to designate the phenomenon of combustion, to which it properly belongs.

By introducing the proper salts into the carbon, on becoming heated by the passage of the current, they are volatilized and rendered incandescent. The hot gases thus generated furnish a path of less resistance than air for the passage of the current and thus permit of the electrodes being drawn much farther apart, thus producing an arc of much greater length (1 to 2.5 inches) than is formed between pure carbons.

The light being produced, as just stated, from the salts in the carbons, is of a different color, according to the nature of the substance used. With

the calcium salts it is of a golden tint, hardly distinguishable from the color of light of ordinary flames and incandescent electric lamps, a fact which was happily expressed by an observer who, on first seeing the illumination produced by such a lamp, said "It looks like a bon-fire." This yellow-colored light is, for purposes of exterior illumination, a decided point in its favor. The fact that blue light is the first to be absorbed by smoke and fog is well known, as shown by the red color of sunlight when seen under these conditions. The penetrating power of the yellow light of the luminous arc is far greater than that of the blue and violet light from the open arc. For lighting foundries, iron mills, railway yards or any other large enclosure where smoke abounds the same advantage maintains.

The various workers along these lines have not been satisfied, however, with the production of light of yellow color only, but have sought to produce light of daylight quality, or so-called white light. The mere production of white light was not a difficult matter, but it was found that carbon producing white light were much less efficient than those producing the yellow. Recent improvements, however, have been made and at the present time carbons giving a white light of remarkably fine quality are produced. It is claimed, doubtless with perfect truth, that the white light thus produced is the nearest approach to sunlight of any of the commercial light-sources.

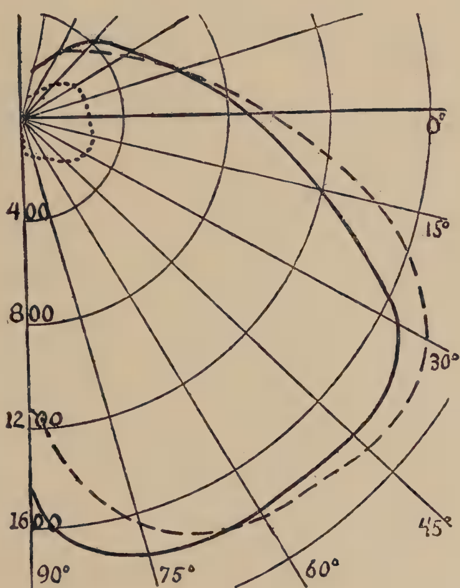


FIG. I.

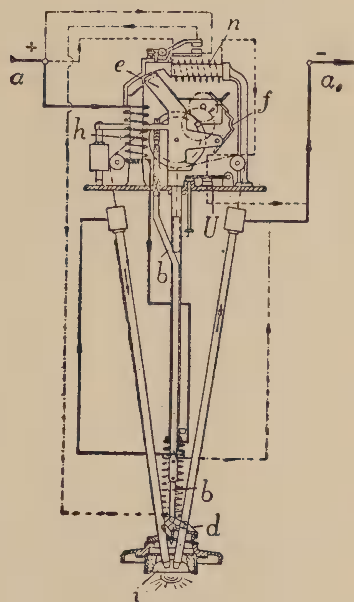


FIG. 2.

In the matter of efficiency as a light producer the luminous arc is revolutionary. Measurements made by the Electrical Testing Laboratories with lamps producing the yellow light gave the following results, as compared with an enclosed arc:

	Luminous Arc.	Enclosed Arc.
Mean amperes	8.	5.1
Mean volts at arc.......	45.	81.
Mean watts at arc.......	360.	413.
Mean spherical c. p.......	1020.	232.
Mean lower spherical c. p.	1560.	260.
Watts per m. s. c. p.....	0.353	1.78
Watts per m. h. c. p......	0.265	1.59

In actual light production the luminous arc is therefore practically five times as efficient as the enclosed arc. The lamps tested were run on direct current and were fitted with opaline globes of practically equal density.

While the price of the carbons themselves is higher than the price of the best pure carbons, the cost per candle-power hour figures out exactly the same. The smaller lamps run ten hours with one setting of carbons and the larger lamps fifteen hours.

It was found necessary by reason of certain special conditions to materially modify the mechanism of the lamp itself for the successful use of the luminous arc carbons. Fusible matters introduced into the carbons have the tendency to form drops of slag, which interfere with the operation of the lamp if the carbons are placed one above the other. It was therefore found necessary to resort to an arrangement of the carbons side by side and inclined toward each other at a slight angle; thus again reverting to the arrangement of the Jablachkoff candle, the earliest form of arc lamp to be publicly used. This necessitates the use of an electro-magnet placed above the arc to give the arc a downward curve and prevent its running up the sides of the carbon. This arrangement has the advantage of giving a natural distribution entirely free from shadows underneath. In practical construction a concave porcelain plate or cup is placed immediately above the arc, which protects the mechanism, steadies the arc and acts as a reflector of the upward rays.

Prof. Blondel has designed a luminous arc lamp in which the carbons are placed one above the other, as in the ordinary form. The construction of the carbons is also different, from other commercial forms; but as the lamp has not yet entered the commercial field, at least in this country, it does not at present enter into a consideration of the practical side of the question.

The distribution of light from the lamps now on sale in this country is practically the same as from the enclosed arc when used with opaline globes. A comparison of the two curves from the tests above referred to is shown in Fig. 1. For exterior lighting a somewhat broader curve would be rather more desirable.

Owing to the much greater size of the light-source the intrinsic brilliancy, even with the lamps giving much higher total candle-power, is far less than with the ordinary arc, except where the latter is diffused with very dense diffusing globes.

With the carbons giving a white light the efficiency is said to be reduced about one-half, but even in this case the efficiency is more than twice that of the enclosed arc and the quality of the light superior in being free from the excessive blue and purple rays.

On account of its greater length the arc is naturally very sensitive to air currents and it is therefore necessary to protect it from drafts. Since there is also some vapor generated, which muct be allowed to escape, provision must be made for a restricted access of air and the discharge of the vapors. This is accomplished by providing a small inlet at the bottom of the globe and a corresponding protected outlet at the top.

Lamps are made to run on either direct or alternating circuits and on frequencies of sixty cycles and upward. As they require about 45 volts to the arc they are run two in series on 110-volt circuits or corresponding series on higher voltages. The mechanical and electrical operation of the lamps as sold in this country seem to be entirely satisfactory. Thus far only lamps of foreign manufacture have been sold here, the general design of which is practically the same. One is manufactured in Germany and the other in England. The arrangement of the mechanism is show in Fig. 2. The lamps sell for about fifty dollars each.

As the real virtue of the lamp lies in the composition of the carbons,

these are naturally claimed by the different manufacturers to be either protected by patents or kept secret. As the fundamental patents have long since expired, it seems unlikely that any monopoly can be maintained in this respect. The "trade secret" claim is one of the peculiar chimeras which often serve to deceive even the manufacturer himself. In the present state of analytical methods, together with the susceptibility of the ordinary employee to the seduction of "graft," it is next to impossible to maintain the formula of any particular compound as a secret.

The most serious objection that can be urged against the lamp at present is the greater amount of attention required. It is in this line that efforts are at present mainly directed toward improvement, particularly toward combining the long life of the enclosed arc with the efficiency of the luminous arc. In view of the enormous increase of efficiency obtained, the improvement in the color of the light, its steadiness, and naturally advantageous distribution, together with the rapid improvements that have been made within the last few years, it is safe to predict that the luminous arc lamp marks an epoch in electric illumination.

INVERTED GAS MANTLE LAMPS

By Victor A. Rettich

Opinions seem greatly divided as to the ultimate success of the inverted burners, some contending that to burn gas downward at the ordinary house pressure of less than two inches, is like trying to send water up hill without the requisite force in the pumps so to do. After a long discussion at a recent convention in England the verdict then was that the inverted lamp in its present form would not be a success. At the same time, no suggestions were put forward towards altering the anomalous condition. On the other hand, it is contended that in preparing fowl for the table, a bunsen burner burning downward to remove the little pin feathers, acts just as well as when erect. Each of these arguments is right, and yet each is wrong. The burner for singeing has no mantle on it, and is getting a full supply of oxygen to combine with the flame and if, after prolonged use, the burner does heat up all the way, it matters little if the flame does have a tendency to show a luminous tip. When, however, the same flame is enveloped by the mantle, the interstices or meshes in the knitting will seize upon and hold the free carbon with the consequent blackening of the mantle.

When the gas is burning downwards at a low potential energy and all the parts are cool, it is enabled to give kinetic energy to the surrounding still air, but once the heating process is started, the air is no longer still, but, being rarified by the heat, commences to perform its physical function of convection, that is, rising by rarification. Therefore, unless the potential energy is sufficiently strong to overcome the upward tendency of the air, it is obvious that the gas must go through by itself without being previously mixed with air and so deluminized by the process of oxidation, cooling and dilution and, consequently, burns with a luminous tip.

Further, the mantle itself in its present form must cause a back pressure and so retard the rapid efflux of the mixed air and gas at the burner head. It seems to me that the knitting of the mantle has not been carefully studied out in the manufacture of inverted lamps. A mantle of thicker cotton but with interstices of a much greater area should produce one of the same tensile strength as the present one and decrease the back pressure in the burner at the same time admitting more oxygen to its interior. In a paper which I read before the National Commercial Gas Association, on January 25th last, I stated that the original incandescent gas burners had been made with the mantles underneath the burner, but in these cases the gas was under pressure so that the potential

energy of the gas could do the necessary work to maintain perfect combustion and, doubtless, where a light gas of low candle-power is supplied at a pressure exceeding 2-in, the inverted burner will give good results, but with New York gas of about 23 candle-power, with the pressure averaging 1.2 in. to 1.5 in., the problem is a very difficult one to solve.

In 1895 an English patent was granted to Hancock, Craig & Hancock for an inverted burner, constructed so that no air is admitted to the burner to mix with the gas, the carburretted air or a mixture of air and gas being supplied to the burners already mixed and in proper proportions for burning and later in the same year a further patent was taken out in which the burner took in its own air. As far as I am aware neither of these burners was ever placed upon the market. I have a further recollection, but no data at hand, of the Rawson Bros., whose name is always associated with the collodinizing process for the mantle, taking out a patent for a similar device, especially applicable to railway lighting. The short notice given me to prepare this paper does not permit obtaining the exact particulars of this invention though it is distinctly within my memory.

It would seem that inventors were trying to imitate an incandescent electric lamp, for on looking over back patents, I find a patent granted to Bernt and Cervenka on October 15th, 1901, for an inverted burner and on August 19th, 1902, one granted to Trenesreuter for a downward appearing lamp, that is, in which the shadow is reduced to a minimum. Both of these applications were filed in the year 1900, and each has the same object in using a heat insulator or isolator between the point of combustion and the gas inlet and nearer to the ignition point, each with the end in view of assuring an intake of cold air. In Tresenreuter's specification, claim is made for preheating the gas. Upon the merits or demerits of this process, it is not my intention in this paper to argue, though I strongly favor the idea of delivering gas and air at the coldest temperature possible.

During my recent visit in Europe I was told that the sale of the inverted lamp was something enormous. Still I must confess I failed to see that even a small percentage of the burners in use were of the inverted type and if under the conditions met with there, that of a ten to fourteen-candle gas delivered at a good pressure, they have not been popularized, I cannot see that the burners in their present form are going to be a permanent addition to gas lighting appliances. The inverted burner has been on sale in Europe for the last four or five years and yet today a tremendous majority of burners are of the upward type fitted with a straight glass chimney and by means of suitable shades the light is directed exactly where required. One must cheerfully admit that the possibility of graceful outlines and designs is greatly extended when the gas is caused to burn downwards, but so far the public have not taken very greatly to the designs in which the mantle is so placed and the globe is so shaped as to present the appearance of an electric incandescent lamp.

In 1899 or 1900 a large corporation of New York produced some very handsome designs in which a small upright burner was used and a stalactite or electric shaped globe provided to cover in the entire burner and bring the mantle in the exact position of the electric lamp filament, the whole presenting a resemblance to the decorative effect that one generally associates with electricity, yet the sale proved extremely limited. Whether they were four or five years too early with their designs, or the price was too high, remains to be seen.

After a long series of experiments it seems that if, on first lighting, the burners ignite without flashing back and without noise, it will only be a short time before they will carbonize the mantle. If on the other hand when the burner is so regulated as to give violent ebullition on start-

ing and in the course of five or ten minutes be silent, under most conditions this lamp will give the best results. I am aware that it is asking the public to strain a point to submit to a poor light for the first five minutes and listen to a roaring noise, but they will be amply rewarded by the good light and silence that they will have when the equilibrium of the burner is found and maintained.

I have noticed how difficult it is, when using a goose neck, to set the burner exactly where I wanted it without experimenting with a number of washers. To overcome this I consider a lock nut with burner thread should be sent with each, accompanied by instructions how to connect.

We must look for an improvement in the method of connecting the mantle to the clay or other holder. Experience teaches that there is a strong inclination for these mantles to fall away at the point at which they are fastened to the holder. When a mantle is constructed for an upright burner the head is always strongly re-enforced and pleated, but with the inverted burner only a single thickness of the fabric is utilized to support the entire weight. Now, if the inside of the knitting were doubly or trebly folded and sewn together and then the asbestos thread tied around the entire double or triple thickness, a much better cushion would be provided at the weakest point. This may reduce the candle-power slightly, but this loss will be compensated for by the lengthened life of the mantle.

The inverted burner has been recently condemned in New York City by the Board of Fire Underwriters on account of fires having actually started and many billiard tables, etc., having been charred by red hot carbon falling through the open base of the globe. Of course, the mantle itself will be cold the instant it is broken away from its holding, but red hot carbon is able to continue to glow long enough to do damage. Perhaps if the inverted burner can be constructed so perfectly as to avoid carbonization of the mantle, the restriction of the Underwriters may be withdrawn or they may be satisfied to have the globe without any bottom openings.

To classify the defects and objections to the inverted lamps we find the following:

1. Dangers of falling particles.
2. Carbonization.
3. Flashing back.
4. Delicacy of mantle suspension.
5. Flickering light at low pressure.
6. Discoloration of chandelier arms.
7. In many cases a difficulty in attaching lamps so that they will be gas tight when set in the required direction.
8. Methods of gas regulation are too coarse. A much more delicate way is required.
9. Liability of breaking mantles when removing glassware.
10. Variations of diameters of globe rings, so that glassware is not interchangeable with different makes of burners.
11. Variations in means of affixing mantles to burners. Manufacturers should get together and adopt one standard type, though each is naturally trying to protect his future trade in renewals. Still the public ought to be considered if the lamp is to become popularized.
12. Too much heat thrown off in proportion to the amount of gas used.

Varying claims are made as to the efficiency of the inverted burner. Whilst there can be no doubt that the light is vastly greater than the ordinary 16 to 32 candle-power electric bulb, still the light is so brilliant and glaring that it has to be toned down by ground glass or opaque shades, so that the actual candle-power that is utilized is not to be compared with that obtainable.

It is a well-known principle in illuminating that strong sources of light should be avoided as much as possible. Therefore this present seeking after high candle-power for the inverted burner must eventually resolve itself into placing them higher on the fixtures than are the present upright

burners or else three or four smaller burners, so that they are above the line of vision, or else three or four smaller burners must take the place of one larger one.

When the regenerative gas lamp was brought out it was then considered a large source of light. This lamp can justly be termed as being of the inverted type insomuch as the whole of the light was directed downwards and the flame beneath the burner. These lamps were generally fitted as near the ceiling as possible and by means of a suitable reflector an even distribution of light resulted, but the origin of light itself was too far removed from the eye line to make itself obnoxiously felt.

When the miniature regenerative lamps came out for hanging on the chandelier in the same manner that we are to-day doing with inverted lamps each individual burner did not exceed ten to fifteen candles and being of a yellow color did not obtrude itself on the retina of the eye.

I shall take pleasure now in showing you several drawings of various types of burners, some of which are upon the market. It would ill become me to make any comment on any of them, but I show you these sketches so that you may see the trend of inventors' thoughts.

Fig. 1 is a drawing from the patent records of one of the earlier inventions of 1895 granted to Hancock and others. It will be noticed that the gas flows through the tube 1 which forms the mantle support at 2. This tube carries the gas downwards to the burner head, screw threaded at its lower end 3. The gas is then expelled through small openings 4 in a diaphragm entraining air through the parts 5 provided for the purpose and then burning entirely within the mantle at the gauze head 6.

Fig. 2 is another form covered by the same patent which is of the type of the inverted burner we are using today. It is interesting to note the primitive methods then adopted for suspending the mantle downwards. It was done by means of a wire cage connected to a suitable holder 1, permitting the mantle itself to lie within such cage. A very good point in this lamp is the hinged joint 2 permitting the easy removal of the globe.

The next sketch, Fig. 3, may be termed the pioneer of the present series. This is the Austrian one before referred to, its special claims for notoriety being the porcelain cone 1. The burner tube 2 is claimed to be of a bad conducting material, though later on in the specification it is stated that the burner head 3 is made of metal, yet the tube 2 forms part of the head 3 and if the head is of metal then the tube must be of the same material. It, therefore, makes this specification rather of a contradictory nature. Our later knowledge shows us that the mantle is not of the best shape for inverted lights. A deflector 5 is provided to keep the products of combustion away from the air ports.

Fig. 3 type has been considerably improved and is marketed to-day as shown in Fig. 4. An adjustable gas check has been found necessary to suit the varying pressures and the porcelain cone has been extended both upwards and downwards as at 1 and 2, so that its narrowest point 1 now becomes the burner head and the outwardly flaring portion 2 acts as a light reflector and a heat diffuser with the object in view of keeping the air inlets as cool as possible.

One of the earliest attempts to put a burner on the market after the previous one had become known in England and Germany is the one shown in Fig. 5. As previously explained, when air is heated it quickly ascends. The inventor took advantage of this fact of ascension to collect it in suitable tubes 1 and 2 and send it to mix with the gas in place of depending entirely upon suction.

Fig. 6 is very interesting. It shows a means of deflecting the heat, of collecting the air from outside the burner itself as at 1 and 2, and a means of regulating each air port, but what strikes one most is the ingenious meth-

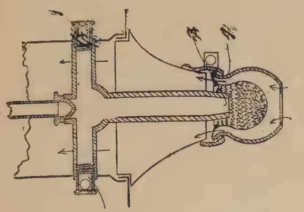
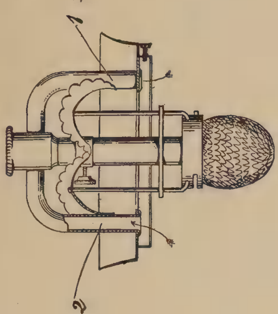


Fig. 6.



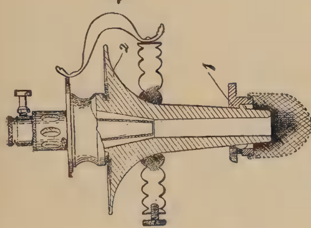


Fig. 4.

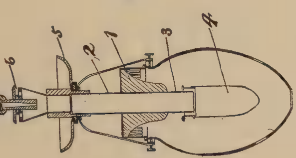


Fig. 3.

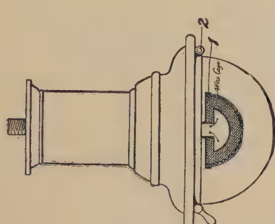


Fig. 2.

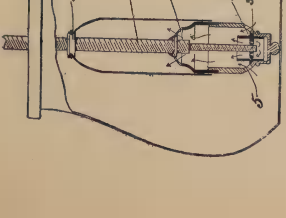


Fig. 1.

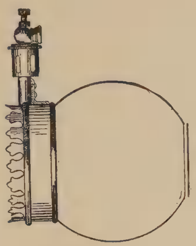


Fig. 12.

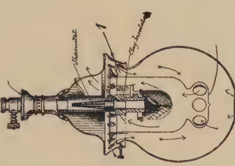


Fig. 11.

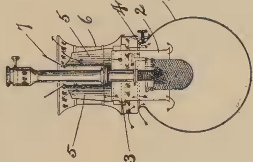


Fig. 10.

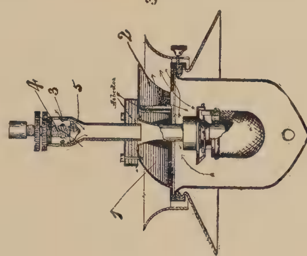


Fig. 9.

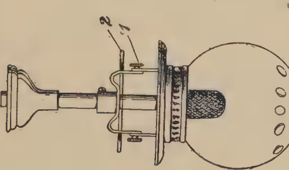


Fig. 8.

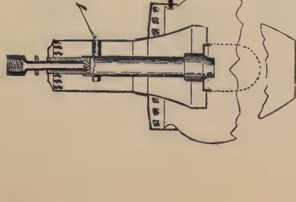


Fig. 7.

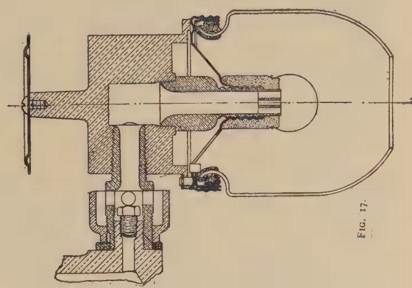


Fig. 17.

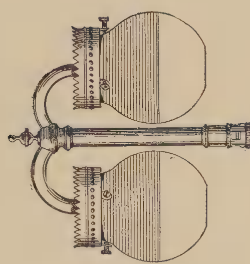


Fig. 16.

Fig. 15.

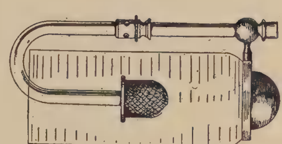


Fig. 14.

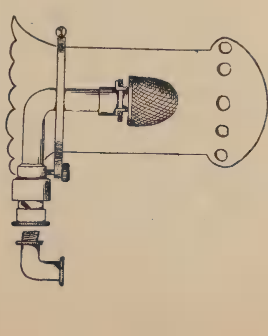


Fig. 13.

od of attaching the mantle to a small globe 4 and then connecting the globe to the burner itself. As far as I know, this is the only burner which makes use of a tapering nose piece to form the burner head.

The next burner, Fig. 7, is now on the American market and presents a similar idea, inasmuch as it takes its air from outside the burner itself as at 1.

Fig. 8 has no special merit, but simply shows a novel method of detaching the globe by means of thumb screws at 1. It is also provided with a heat deflecting plate 2. This burner is extensively advertised in the German trade papers.

Fig. 9 is a burner to which apparently much thought has been given in its production. It will be noticed that by means of asbestos the entire bunsen portion of the burner is separated and insulated from the lower part. A chamber 1 is provided over the burner for collecting the heated air. It is then projected through a single opening 2 so that the chandelier or bracket arm will not be discolored by the products of combustion. The method of the air intake seems quite ingenious, for although the air ports themselves 3 are always completely open, yet the burner, on revolving up a screw threaded tube provided for the purpose 4, chokes off the air at 5 until the correct mixture is obtained, and then a lock nut secures it permanently when the proper position is arrived at. It will also be noticed that the method of supporting the perforated globe is quite clever. It can be used either with or without a shade, and is so arranged that if the shade is used the globe fits inside of it and thumb-screws will support the shade and, of course, the globe with it.

Fig. 10 is a very novel burner, inasmuch as it permits an outer globe to be used which is entirely closed. This outer globe 1 contains a straight chimney 2, which by means of suitable catches 3, can be supported entirely free from the outer globe, and air can be taken in between this chimney and the outer globe as at 4 and then sucked in at the bottom of the mantle as shown by the arrows. Above this are provided two iron chimneys 5 and 5 contained within a brass casing 6. Each of these chimneys is provided with a sloping cover 7 which sends the heat forward and away from the central tube, again with the idea of preventing the products of combustion from creeping back to the air ports.

Fig. 11 is one of the latest to enter the field and seems to combine many of the good points shown in its predecessors. The outer globe and the inner globe are usable at will either together or singly as shown in a similar way in Fig. 9. The air intake may be above the mantle as at 1 as well as below, so that an entirely closed outer globe may be used as shown in Fig. 10, but if in the event of one with an opening, as shown, being adopted, the bottom of the perforated inner globe is provided with a saucer 2 at its lower extremity to catch falling particles. The take-off of the heated and consumed air is from one side as shown in Fig. 9. It will be noticed that the adjusting screw is fastened on the side opposite to that by which the heated air is thrown off. A distinct novelty is that of using a thermostat. This thermostat is arranged in a direct line with the flow of gas. When the burner is cold the narrow ends of the thermostat will be bunched together, forming a slotted cone and offering a resistance to the mixed air and gas and so to soften the flame as to permit of lighting without flashing back. As soon as the burner is thoroughly warmed up the action of the heat on the thermostat fingers will cause them to open and lie flat against the inner surface of the tube, thus offering no obstruction to the descending gas and permitting it to take in a full complement of air.

All the foregoing inverted burners have been so constructed that the gas was carried to the burner and then sent at full force in a downward direction. Attempts have been made to send the mixed air and gas in a horizontal di-

rection and then bent downward as is seen in Figs. 12 and 13 and have also sent upwards and then round in a complete horseshoe as shown in Figs. 14 and 15. The mixture has also been carried up and divided as shown in Fig. 16. With these last mentioned types of burner, lighting back is nearly overcome owing to the speed of the gas being so greatly reduced, but with such a soft flame it requires but a very slight drop of the pressure to cause the mantle to become full of carbon.

Fig. 17 is the type that is used for railway lighting and one that appears to have given very great satisfaction. A peculiarity is the way in which the mantle is attached. It will be noticed that there is no annulus or opening between the mantle holder and the burner tube, that is, the mantle is continuous with the tube so that no products can escape. The combustion of the burner is absolutely perfect and consequently no carbonization of the mantle follows. But this brings us back to the old question of pressure. The supply of the Pintsch gas is at one pound pressure, roughly speaking 28 inches of water pressure. With gas at this potential energy and the tiny orifices through which it is forced, the amount of air induced is very great so that the lighting is of the highest efficiency. Strange as it would appear, the mantle life in this railway service is remarkably long, from ten to twelve weeks, which is about the life of the electric bulb. Although not clearly shown in the drawing, the mantle carrier and globe are fastened together and are attached and removable when so joined. In the case of a renewal, the porter of the train unscrews the globe, bringing with it the mantle holder and replacing it with another globe containing a fresh mantle quite as quickly as an electric bulb is attached. This, I understand, may be done without shutting off the gas supply as this mantle can be burned off just as well when gas is inside as otherwise.

We have now examined three separate and distinct types of inverted burners and it would almost seem that any piece of tube with holes drilled at one end for an air intake, furnished with a regulating check and means for carrying a mantle and globe, will give a good result in the hands of a person well versed in the art. It will burn for a considerable time, giving satisfaction, but somehow as soon as it reaches the public, no matter how carefully the details have been worked out to render it fool-proof, it is only a matter of a very short time before they are discarded and the upright burner again installed.

In conclusion I may say with our English brethren, that the problem is not yet solved, but with so many capable engineers all over the world at work on the subject, a good, reliable and simple lamp must be evolved and then gas consumers will be provided with a burner that will give at least 60 candle-power, on a consumption of not more than three feet and when the fixture designer gets in his good work by constructing fittings to suit the burner an enormous field will be opened up and the public will welcome the advent of an appliance that will give the decorative effect of an electrolier, but with more light and at a greatly reduced cost.

Gas men must join me in hoping that that day is not far distant.

ILLUMINATING ENGINEERING FROM THE ARCHITECT'S STANDPOINT

By Waldo S. Kellogg.

This paper will touch upon a few of the general features of interior illumination while attempting to outline the architect's interest and his relation to others interested in the same subject but from a different standpoint.

The high intrinsic brilliancy of most lights is largely, I think, responsible for an immense part of the light usually wasted. In figuring on a high

efficiency the maker forgets that the dazzling effect of an unshaded light so blinds the eye that a much higher degree of illumination is required. In thus getting, for advertising purposes, a slightly higher theoretical efficiency practical considerations are lost sight of. If the makers of lamps considered the best interests of the consumer, rather than the seller of current or gas, well shaded lamps would be the rule and not a special article supplied reluctantly at a price calculated to discourage their use.

The so-called 16-c. p. lamp has become the generally accepted lamp, but recently the tendency seems to be toward more powerful lamps, not because there is a demand for them, but by reason of improvement in lamp efficiency. It was remarked above that manufacturers catered to distributers of light, hence to induce them to take up their lamps, new units are made up using the former amount of gas or current and a great noise is made about the intensity of illumination. If the public can get an inning, it may pay to advertise: We can give you the same light for half the money; instead of as now, for the same money we can double your illumination.

There is no generally accepted standard lamp rating except such as best suits the eccentric distribution of the lamp for which at that moment some manufacturer is claiming the merits of all other lamps besides other virtues. The candle is a reasonably satisfactory unit of measure, but the rating of lamps in candle power should mean something and enable one to judge what the illuminating value really is. Spherical candle power rating is a fair basis of comparison, but the reflector lamps now being introduced and the devices for turning all the lights into the lower hemisphere seem to make the present prospects poor for the adoption of a logical spherical rating.

Until the spherical rating is adopted no one, except he is able privately to ascertain the true rating, is prepared to say that a certain intensity of illumination can be obtained by using a given number of lamps of one kind or a different number of another kind. If without means to get data, he must to protect himself, put in outlets for two, and to be really safe, three times the number of lamps the manufacturer's rating in candle power calls for and the client is apt to complain of large lighting bills. It is in this necessity for protecting himself, that the architect lays the foundation for the unpopularity of the light distributer.

In all cases a lamp should be so constructed as to harmonize with its architectural surroundings. In a carefully designed building the lamp, with as small a sacrifice of efficiency as possible, must conform to the architectural background. Thus, when a manufacturer professes to be unable to adopt a standard design to suit the architect's ideas, he must expect to be told that if such is the case the lamp will not be used, as considerations of efficiency are of less importance than the æsthetic ones.

The color of any light plays a more important part than some manufacturers like to believe. Man has become so accustomed to the warm glow of candles or similar light that in domestic work he prefers a light of this color and a bluish white or greenish white light will be used only when a very strong light is needed. Women say that candle light adds to their natural attractiveness and with them in opposition the sickly light is very heavily handicapped.

The architect is employed to make a structure both convenient and beautiful and in doing this it is often necessary to sacrifice so-called practical considerations for others of an æsthetic nature naturally of great importance in the practice of a fine art.

Discussion of the Papers

Before opening the general discussion, the President invited Dr. E. L. Nichols, Professor of Physics in Cornell University, to address the meeting.

Dr. Nichols—Mr. President and Gentlemen: It is quite by accident that I happened upon your meeting to-night, but it was a very happy accident, and I take this opportunity of congratulating the new Society upon the attendance which it brings out at its first meeting and the interest which is manifested on this subject. I really think that in organizing a society for the consideration of the art of illumination and the engineering problems relating thereto, that one gathers together a greater number of interests, scientific, technical and social, than almost any other society of which I have knowledge; and that being the case, I am sure we may look forward to great success on the part of this society. It seems to me certain that your meetings will be of great interest and of great use.

Although we have been using light since prehistoric times, is it not true that at the present time we are still guessing about it—the architect, and the contractor, nearly everybody is still guessing about it; and yet it is an art which is capable of being reduced to a computation which can be made as much a matter of precision as any of the other specifications with which engineers have to deal; and I hope that this society will bring it about, or help to bring it about, that these things in the future shall be attended with greater and greater certainty and precision. We must stop measuring candle-powers, and begin to measure the illuminating effect. We must educate the public so that they will not look at the lights, but will see the effect of the illumination of surroudning objects by these lights. Of course, these things have been more or less dimly understood, and occasionally the principles have been worked out with great success; but there is a great field for the education of the public and also for the education of the engineer himself, and I really think that the organization of the Illuminating Engineering Society is something which will be memorable; that it will take a leading place among scientific and technical bodies, and that it will be an important factor in the development of a very old and imperfect art into a new and highly perfect art. Especially will this be the case if you get the scientific, the technical, the architectural, and the æsthetic interests joined, all working from their own point of view. I shall not say anything about the papers, but I did want to bring this word of welcome to the new society and wish you and all your co-workers success in your undertaking.

Dr. C. H. Sharp—I have been thinking, during the reading of these papers, of the two methods which are here presented for getting light from a stream of heated gases which are otherwise comparatively non-luminous. We have in the case of the mantle an ordinary Bunsen flame which in itself gives no light, but which gives a higher temperature. By introducing into this flame a suitable mantle of solid oxides, a very brilliant illumination is produced. In a somewhat similar way we have the arc stream in the electric arc, of highly heated gas producing very little light. If into this stream is introduced a certain amount of vapor which has the property of radiating light when it is raised to that temperature, this stream of gases also produces a large amount of light. Here, then, are two ways of making an otherwise non-luminous stream of gases luminous; one, by the introduction of a mantle, the other by the continuous introduction of vapor, also of metallic earths. It reminds us of a well-known experiment in which a little common salt is introduced into the Bunsen flame. There we have luminescence, which is analogous to the luminous arc—the non-luminous Bunsen flame is, by the introduction of salt, rendered luminous to a considerable degree. That is what is done with the luminous arc, with results that are so striking. Just why the mantle, which is used in the mantle burners, has the power of producing such an enormous amount of light, working with a flame of very high temperature, is puzzling. This puzzle is rendered all the more remarkable from the fact that the composition of the mantle is restricted to very narrow limits—99 per cent. of thorium and 1 per cent. of cerium combined will produce a mantle which is highly luminous. A mantle of pure thorium produces very little light; a mantle of pure cerium is also very inefficient. If these percentages are varied to any considerable degree, the luminous efficiency suffers at once.

The explanation which has been offered for this state of affairs is perhaps of interest in this connection. The first of these explanations was presented by Dr. Nichols, who suggested that the intense light is the result of the luminescence of these substances introduced into the flame; in other words, that these substances yield a degree of light that is not in proportion to the temperature to which they are raised. A further explanation has been, that the small per cent. of cerium combined with the thorium produces what is known in chemistry as a catalic action, resulting in

a higher temperature of the metal than otherwise would be produced. It has also been claimed that the high luminosity of the mantle is due simply to the high temperature to which it has been raised. A great deal of interest has recently been given to this subject, as the result of experiments made by Prof. Rubens in Berlin, who studied the distribution of the energy radiated by the mantle, not only in the luminous portion of the spectrum, but also in the heat-giving portion. Prof. Rubens has shown that the radiating power of the incandescent mantle is extremely high in the visible portion of the spectrum—the part which affects the eye; that just as we get into the longer rays, the heat waves, the radiating power of this mantle falls enormously, to as low a value as one per cent. as compared with the radiation of a flat body. This radiating power again increases when it comes to the long wave lengths, but the amount of energy involved in the long wave lengths is very small; consequently we find, in the case of the mantle, a body which is radiating almost all the energy given to it in the form of luminous waves and very little in the form of non-luminous waves.

This peculiarity has been further investigated by Prof. Rubens by determining the character of the energy curve of the pure thorium mantle. He finds that the pure thorium mantle gives very little energy in the luminous spectrum, and is practically a transparent body, so that its radiating power with the non-luminous waves is very little indeed. In putting a thorium mantle into a Bunsen flame, very little energy is radiated by the mantle itself, the radiation being almost entirely due to the flame. A mantle of pure cerium, on the other hand, shows a considerable radiation, a large percentage of its radiation, in the luminous portion of the spectrum. It is also a moderate radiator of the heat waves, but not so poor as the thorium; in other words, the cerium is a colored body, its color being a lighting color and not a heating color; consequently by adding a small percentage of this colored body to the thorium it has the result of increasing the efficiency of the thorium as well as extending the radiating power of the thorium to the heat waves, while it adds enormously to the radiating power of the light waves; consequently, the combined elements radiate rather fairly the heat waves, and very well indeed the light waves, the radiation of the light waves being due to the addition of the cerium. The result is that the mantle reaches a temperature which must be nearly equal to the temperature of the Bunsen flame, and consequently there is a very highly luminous condition.

Regarding the flaming arc, I think one thing which impressed us here to-night is that in handling a unit of the enormous power which this arc has, it is necessary to adopt a procedure which is rather different from that ordinarily adopted in the case of the enclosed arc. This light is of such very great power that it needs to be gotten away from the field of vision, to be put away from the surface which is to be illuminated, and made comparatively inconspicuous. Placed as we see a good many of the flaming arcs in New York City at the present time, it has a very bad effect upon the general illumination. It is like putting an Eiffel tower in the city of Paris; it is so much above the ordinary level of the illumination we have, even on such a well lighted street as Broadway, that it has a very deleterious effect upon the general result. It is to be hoped that in handling this lamp, if it is to come into general use, precautions will be taken to prevent ruining the general effect of the illumination by the introduction of indiscriminately scattered units of such enormously high luminosity.

Dr. E. L. Nichols—What I said to Dr. Sharp may be said to be only a surmise or a guess, but it is a surmise based on certain peculiarities, which are, to say the least, suggestive; and while I should not for a moment like to insist upon the accuracy of the guess, it may possibly be of interest if I should point out on what that was based. In studying luminous substances, we note the following facts: To produce luminescence, a substance which will be phosphorescent and fluorescent, you have to have the same peculiarity, namely, a substance which acts as a solvent, and then a small admixture of a dissolving substance; and you must not have too much of the dissolving substance. There is a certain amount necessary to secure the best effect. In the case of luminous paint and other sulphides and silicates which are strongly phosphorescent or fluorescent, that is also true. This admixture may be of manganese, or copper, or other elements. This is evidently a peculiarity which suggests a relationship. It is necessary in the mantle to have a substance such as thorium oxide, and mixed with that a certain small amount of another substance in order to get light.

Again, all substances which are luminescent are luminescent at some particular temperature, some at very low temperatures. There are many substances which are luminescent at the temperature of liquid air, and entirely inactive at ordinary temperatures; others are strongly luminescent at ordinary temperatures and are entirely killed by cooling to the temperature of liquid air. I think it is quite possible that the luminescence of the solid solution which we may have in the case of a mantle, a solid solution possibly consisting of cerium moving around in thorium oxide, may be strongly luminescent at the temperature of the Bunsen flame.

There is another fact which leads to that conclusion—that all known luminescence lies within the spectrum and consists of a single broad band of light, having one well defined maximum, but not usually covering the whole of the spectrum. If you explore the energy of the spectrum of a mantle burner, you will find this gain corresponds with luminescence. It has the maximum within the visible spectrum, and the form of the curve is not unlike that of the form for the spectrum or other luminescent bodies. While we are not ready to say definitely that this is the explanation of the remarkable light-giving power and peculiar distribution of light from the mantle burner, I think there are certain facts which warrant a guess of this sort. I hope some day to investigate the matter and be able to demonstrate it one way or another. The fact brought up by Dr. Sharp of the great weakness of the spectrum of the mantle is certainly extraordinary, in fact unprecedented. It is certainly a very beautiful subject for scientific exploration, and as all scientific exploration in the end is of some use. I think it is possible this subject, after it is worked out by men of science, may lead us to the development of other sources of light akin to this, but differing from it in distribution, so that in the end we may be able, perhaps, to produce a great variety of luminous spectra and thus get mantles which will give almost any sort of light which may be desired for the various purposes for which light is employed. Sometimes we want light of a rosy hue—light almost of a cherry shade—at other times we want brilliant white lights, and lights running over into the blue edge of the spectrum. Certainly, the ultimate development of this form of light must lead to something of that kind.

Mr. G. G. Ramsdell—It would be a rather difficult thing to discuss a matter as technical as the subject dealt with by Mr. Rettich in his paper. It is well prepared, and there is a great deal of truth in it. Unfortunately there is a great deal of error in it also. I presume if I were writing the paper, I should be as optimistic as he is pessimistic. I do not think there is any doubt that the inverted lamp is going to be a success. I do not think any one has yet claimed that the inverted lamp is entirely perfect, but if you will compare it with other lights, you will be forced to admit that it is only passing through the stages of evolution that all the other lights had to pass through. The electric light of early years, as compared with the electric light of to-day, shows a very wide difference, and that is true of all lights. While the lamp is in its infancy very largely, yet there have been great strides made in the improvement of the lamp, and to-day it is very much more successful and much nearer perfection than it ever was before.

Mr. Rettich—If Mr. Ramsdell had listened carefully to the paper, I think he would have heard the statement made that the lamp in its present form was not as successful as could be wished; but that with so many capable engineers, and Mr. Ramsdell himself among them, improvements in the lamp must be evolved, and will be evolved, but at the present moment the lamp is not a complete success.

Mr. E. C. Brown—As to the electrical features of the discussion this evening, I do not feel I am competent to enter upon a discussion. I would say, however, in reference to the inverted gas lamp, that I have listened with a great deal of attention to what Mr. Rettich has given us in his paper. I would like to say that one of the first inverted lamps which came to this country was installed in my office, something over three years ago, I think. We had with it only one mantle. It was an imported lamp, and an imported mantle. To the best of my recollection, that mantle lasted nearly eight months, and during all that time the light gave the best of service. We were sorry when the mantle finally gave way. The lamp was the same type of lamp which, I think, now belongs to Mr. Ramsdell's company; and a comparison between what we had, and still have, minus the mantle, in that one lamp, and the lamps Mr. Ramsdell's company is now turning out, shows a most marked difference. I have the utmost faith in the future of the inverted gas lamp, because the light effects are remarkable, and I think the slight matters of detail to which Mr. Rettich called attention can all be overcome, if indeed they are not now practically overcome.

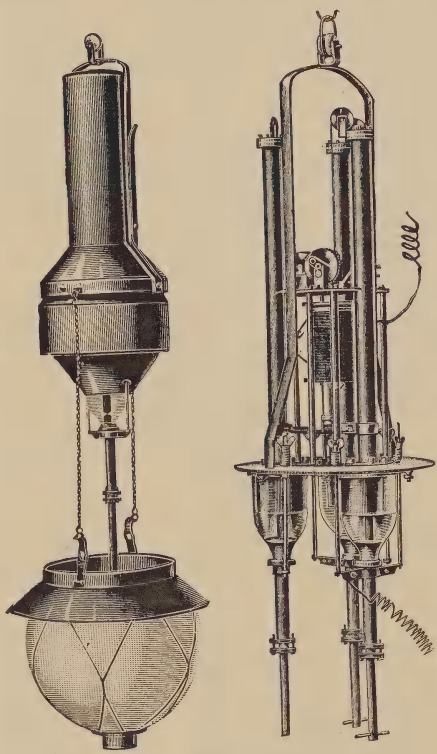
Mr. E. L. Elliott—I would like to ask one question which I have not heard discussed, and that is the actual efficiency of the inverted burner as a light producer, as compared with the ordinary upright burner.

Mr. Rettich—The direct rays are about 60 c.p. With a reflector you can get as high as 110 c.p., on a consumption of three feet of gas—so long as it holds. (Laughter.)

During the reading of his paper on the "Luminous Arc Lamp," Mr. Elliott referrred to a German lamp of this type which claimed to have a life of 1,200 to 1,600 hours. The following description of this lamp is taken from a trade circular issued by the manufacturers:

Our "Vogel-lamp," so named after the inventor, Mr. Vogel, Mechanical Engineer, is a mercury vapor and long burning arc lamp which will burn for 1,200 to 1,600 hours with one single pair of carbons and yield an intense light of 300 to 30,000 candle-power at a consumption of 0.2—0.4 watts per candle; the lamp is of very simple design and does not require daily attendance.

The essential feature of the lamp is that the lower carbon stands in mercury amalgam and when the lamp is switched on, a luminous arc is at once formed, which heats the lower carbon and evaporates the mercury. The evaporation requires only a few moments and increases the luminous arc and the intensity of the light, as the radiant light of the hot mercury vapors is added to the original light of the carbon arc. In consequence of the great conductance of these metal vapors the inner resistance is reduced and a greater and more intense arc of light can therefore act in these lamps than in any other existing type of arc lamps. As the mercury vapors together with the luminous arc are enclosed in a glass globe, the vapors cannot



THE VOGEL LAMP.

escape and when condensed on the walls of the globe they are always returned to their general reservoir.

This design has been patented in Germany and in all other industrial countries; we manufacture these lamps in a variety of types and for different purposes.

They are arranged in a casing with a closed protective globe and can be connected up singly or in series for continuous, alternating and three-phase current. For special purposes also multiple lamps can be supplied, having only one single regulating device and being fitted in a common or joint casing.

The luminous arc in the mercury vapors not only produces a very great intensity, but also a very considerable chemical and optical effect, so that these lamps are better suited than any other existing source of light for photographic and copying work, for medical purposes, for lighting streets and squares, for lighthouses and for searchlights.

The unfavorable color of the mercury light has been avoided by the amalgamation so that we can even supply lamps giving a red light and can recommend these lamps for lighting shop windows, hall and private dwelling rooms.

This mode of regulating is only possible with our lamps, as the consumption of carbon is so trifling and uniform that a regulation is only required after about a week.

PROCEEDINGS OF THE MEETING HELD AT THE AMERICAN HOUSE, BOSTON, ON MARCH 20th

Called for the Purpose of Organizing a Local Branch of the Illuminating Engineering Society

The meeting was called to order at 8:10 P. M. by Mr. Codman. Mr. John Campbell was nominated for the position of chairman, and was unanimously chosen to fill that position. Mr. Campbell then spoke as follows:

Mr. Campbell—I want to thank you, gentlemen, for the honor conferred, and to say that I greatly appreciate it. It gives me much pleasure to call you together to-night and to see so many here interested in the question of illuminating engineering. We have gone a little ahead of the New York society. When the question of a Boston Branch came up, there was some doubt in New York regarding it. They questioned whether we had sufficient members to make it interesting for a local branch. I think that question has been well answered by the attendance here to-night, and also by the numerous replies received from those who were unable to be present, but have expressed their regrets and also their interest in the formation of a local branch here. We take in the different interests, probably, as few other societies do. The contractor, the fixture designer, the architect, the engineer, the electrical man, the gas man and the public are all interested. Now if we can all get together on one basis, and consider ourselves all as engineers interested in the subject of the best illumination and the best methods of obtaining it—if we can drop the question whether we are gas men or electric men, etc., and simply consider the

question from the broad standpoint of illumination—we may expect to accomplish a great deal. Of course we all have differences. That is what will make our meetings interesting; and if we can, as I say, get together on some broad basis, we may then expect to accomplish considerable in the line of illumination. We have to-night two papers, which will be presented later, and we also have the honor of the presence of the President of the New York society, whom I have asked to say a few words to us, and I take pleasure in introducing Mr. L. B. Marks.

Mr. Marks gave a brief review of the formation of the Illuminating Engineering Society and outlined the work which it aims to accomplish.

Mr. Campbell then called attention to the application blanks which Mr. Stickney was distributing, and to the register book which was being passed around. He then introduced Mr. J. S. Codman, who was requested to read the paper of Mr. Victor A. Rettich, on "The Inverted Gas Mantle Lamp," which was presented previously to the parent society in New York. After Mr. Codman had read this paper, Mr. Campbell introduced Mr. E. L. Elliott, of New York, who came over for the purpose of presenting a paper on "The Flaming Arc," which he had also given before in New York. At the close of this paper, Mr. Campbell requested Mr. Cummings to read the discussion which took place at the New York meeting on the first paper, after which he called on Dr. Louis Bell for further remarks.

Dr. Bell—I hardly want to classify myself as a gas man; I must confess to being rather a neophite in this matter, but I see no reason why the inverted lamp should not be a "go." It is merely a question of getting fairly reasonable conditions for forcing the flame into a somewhat unnatural position. It certainly would not go with extremely low pressure gas, but you cannot expect one particular pressure of gas to suit every conceivable kind of illumination. The pressures which are the very best for these mantle burners are too high to work nicely in the ordinary gas flame. The whole question, it seems to me, is getting the right mechanical construction, and gas pressure enough behind it to send down the gas and heat up the mantle properly.

The theory of the mantle burner is a most complicated and troublesome thing, and is marked by this peculiarity, which was brought out in the discussion in New York, that the radiation is selective. It is heated to a very high temperature, but has a luminosity which is much greater than would be accounted for by 1800 degrees C., for we drive up our electric lamps and do not get anything like the luminescent effect that occurs in the case of the gas mantle. The problem ceases to be a question of high temperatures, and becomes a question of high temperatures plus a certain amount of selective luminosity which belongs for some reason to a small group of metallic oxides, of which cerium is one.

It may be stated that it is the selective radiation which gives the luminous arc its value. It is precisely because the light is so bright in orange and yellow that the arc of the flaming variety gives so enormous an efficiency. The white arc of the flaming kind gives a lower efficiency, not because there is anything inherently about white light that should make it peculiar, but because in the white flaming arc substances are added to give enough blue rays to raise the general effect of yellow to one of nearly white, and those blue rays do not produce much effect on the eye. In the white luminous arc, therefore, the addition of a certain amount of energy to add the necessary blue contingent lowers the whole efficiency of the illumination.

In these gas lamps there is a maximum of yellow intensity, and the efficiency in the Welsbach is due to the same cause as in the flaming arc. I see no reason why we cannot turn this upside down and use mantles with the same freedom that we use incandescent lamps. Of course their brilliancy is tremendous, and both of them have to be shielded; but that is the penalty we have to pay for high efficiency.

Dr. Bell—Just a word with reference to some very interesting results in regard to change in efficiency in the flaming arc when equipped with a globe. A great cause of difference in efficiency has been intimated as being due to selective absorption. The ordinary opalescent globe is very absorbent for the rays that are strong in the flaming arc. The effect is precisely as if Mr. Ryan had taken one of his enclosed arcs and put a lemon yellow globe on it. The efficiency then would be about that of a white bean. However, you have eliminated the white rays, and one has to be watchful of the materials which have selective radiation, lest he should obtain some curious results, as such results can be secured merely by getting an absorbing medium that is not right. This is an entirely new phase of the study of lighting that must be dealt with. It seems to me that the weak point of the flaming arc is the very high price of carbons, etc. I am not disposed to make very much of the difference of distribution, because after all, to avoid reflectors may be very desirable, but reflectors are tremendously powerful agents, the most powerful agents we have in getting good and effective illumination.

Mr. Elliott—In regard to absorption, the undue absorption of which Dr. Bell has just spoken, was one point on which I wished to remark. The selective absorption of opal glass varies with the material that is used to opalize it. The opal glass that is made with fluorspar is blue, and that may be the

kind that was used in this particular test. It would act as a color screen; while the opalescent glass made with the phosphates, bone ash, etc., and which is the kind that should be used for this purpose, is orange-yellow by transmitted light. I know I was astonished some years ago in making tests with incandescent lamps, to find how trivial the absorption was when the globes were opalized in this manner. On the test I reported here, as I stated in my paper, the figures I gave were obtained through an opalized globe in both cases. In the case with the flaming arc, it was the globe sent with the lamp from England or Germany, and no doubt was made with phosphate glass. The enclosed globe was furnished with the lamp in this country, and I have no doubt that the enclosed arc got the worst end of the bargain, because the violet would be cut down very much by a globe having an absorption of that kind.

In regard to resistances, I think that is common in all forms of lamps.

Of course, the natural distribution of any light is of importance; but since the great development of the use of prismatic glass in various forms for distributing light, the natural distribution of light has lost much of its importance. It is possible to change the distribution—*i. e.*, any good distribution —and give it any form you want, with a loss of only 10 to 15 per cent., so that the important thing for the engineer to know in regard to any light source is what it does as a light producer—how much total light it gives for the energy consumed. It is then up to the engineer to distribute his light where it will do the most good.

Dr. Bell—In regard to the prices of carbons, I saw an interesting experiment a few weeks ago with a cored carbon. The soft core was removed and the carbon impregnated with a solution of common salt, and they were used with very satisfactory results. They were used in two common direct current lamps, having the resistance removed and being run in multiple. They should have had some sort of steadying resistance. They gave, to my mind, very satisfactory and extraordinary results, simply running them in series, and with the carbons impregnated with common salt. I would like to ask Mr. Elliott if he has made any such experiments—that is, impregnating carbons with some cheap material such as connom chlorides.

Mr. Elliott—I have never experimented directly on the composition of the carbons, although I imagine that the substances for impregnating, when figured to actual fact, are very simple and very cheap, though quite a mystery is thrown around them now.

Mr. Campbell—You see, gentlemen, there is a chance for our chemical engineer to come in and become a member, and give us some information. That is just what we want, to all get together and help each other. I hope every man here will make himself a committee of one to make a success of these meetings, and if each will do this, we can rest assured that Boston will hold its own.

Mr. Marks gave an outline of the purposes for which the society was organized, and pointed out the various channels of usefulness in which future work could be carried on.

Mr. W. D'A. Ryan—Mr. Elliott's paper on the "Flaming Arc" is very interesting, but I must take exception to his statement that it has practically the same distribution as the enclosed arc, particularly as the latter gives a very much greater proportion of its luminous flux in the most useful directions for street lighting. The weak points of the so-called "flaming" arcs in their present form are high maintenance cost, due to expensive, short-life electrodes, high intrinsic brilliancy, unsteadiness, fumes, and poor distribution. For obvious reasons the lamp is not suited for general indoor lighting, and the distribution is not proper for street illumination. At the present time it appears to be used mostly for advertising purposes.

A mere reference to candle power, without an explanation as to how the light is distributed is of very little value. I have here a few roughly plotted curves which show the general candle-power characteristics of a number of flaming arcs. I might mention that these tests extend over a period of about three years. Here we have the Bremer, Bausch (Conradty carbons), Blondel, Excello, and Siemens. These are direct current lamps equipped with light opal globes. The efficiency in watts per mean spherical candle power varies from .5 to .8 watts, depending upon the current, resistance and mechanism losses, and globe equipment, of the different lamps, as they are used commercially. The figures quoted by Mr. Elliott in the Excello efficiency test do not include dead resistance in series with the lamp; this may create a wrong impression when comparing various light-sources.

The second set of curves shows the difference between the light with and without globes. I might mention that the globes used on both Bremer and Excello lamps were very light opal. It will be observed that practically half the light is quenched by these globes. This is no doubt largely due to the partial exclusion of air from the arc, total reflections of the light on the inside of the globe, and to a high selective absorption of the glass for yellow rays.

The third set of curves illustrates the distribution of the direct current enclosed arc, half- and full-open Arc, and the Magnetite or General Electric Luminous Arc as equipped for street lighting service. Comparing the light from the enclosed arc with the open arc, we find that while the distribution of the enclosed is much better, the efficiency

in watts per mean spherical candle power is about half that of the open arc; but notwithstanding this difference in light, several hundred thousand open arcs with their higher efficiency have been superseded, demonstrating that the question of distribution and long life of the electrodes is of the utmost importance, particularly in this country. Without these features it will be just as difficult to introduce the flaming arc in the United States, where we have high cost for labor and carbons and relatively low cost for current, as it is to introduce the enclosed arc in Europe, where the cost of labor and carbons is low and current relatively high.

The horizontal curve on the chart shows the excellent distribution of the Magnetite Arc. For this reason it has superior advantages for street lighting. It also possesses the long burning feature. While the total amount of light delivered is not so great as from some of the flaming arcs, it is a more practical and permanent lamp, particularly as approximately 55 per cent. of the total luminous flux is between the horizontal and 20 degrees below, while with the flaming arcs the average illumination coming between the limits mentioned is about 12 per cent.

In conclusion I would like to say that great strides are being made towards determining the candle-foot or foot-candle constants, whichever you wish to call them, for various lights, so that in a comparatively short time contracts will be taken for lighting buildings on this basis. This has been made possible by the construction of a satisfactory candle-foot photometer which works with very fair accuracy.

The following letters, received by the Chairman, were read previous to the presentation of the papers:

General Electric Co.
Boston Office,
84 State St., March 19th, 1906.

Mr. John Campbell,
Electrical Auditing Co.,
Boston, Mass.

Dear Sir:—Referring to your kind invitation to participate in the organization of a Boston Branch of the "Illuminating Engineers Society," I regret exceedingly that I find it necessary to be absent from the city on the date named, but I am pleased to take this opportunity of assuring you of my hearty appreciation of the scope of such an organization if it is organized on broad principles.

While for the last few years the larger proportion of my efforts have been devoted to the power end of the electrical business, I spent a number of years previously in connection, and incidentally in recent years, in illuminating engineering, and thoroughly appreciate the cut and dried methods that heretofore have largely prevailed in connection with illuminating engineering, both from an electric light and gas point of view.

While a few electric light engineers have specialized in this line, even fewer, if any, gas engineers have, and the consequences are that the unfortunate Architect, Mill Engineer, City Engineer, City Electrician, Supt. of Lamps, City Officials, Landscape Engineers, and others whose interests would be largely promoted by education in this line, have had neither the facilities nor the opportunity for acquiring any education in this line, to the extent that in many cases inferior results have been obtained where facilities were ideal, and in many cases the public service company or the gas or electric manufacturer, or all, have suffered in consequence.

There are many cases which we can all call to mind where the illumination of a property has been very poorly laid out by one credited with knowledge in this line, which has resulted in the abandonment of the project, due to resulting expenses, when if properly engineered in the beginning much more satisfactory results could have been obtained at much less expense in first cost and operation, which would have resulted in benefit to all concerned.

It is in part for the above reasons that I feel that an organization of this kind can be made of immense benefit to not only the electrical industry but to the gas interests as well as to the public if it is not made too exclusive. If judiciously organized and conducted there is certainly no reason why, through this medium the Electrical, Gas, Mill, City Engineer, the Architect, City Official, the Public, and all interested can not be brought together to their mutual advantage.

I regret exceedingly my inability to be with you, but wish you every success and assure you of my hearty endorsement.

Very truly yours,
(Signed) Chas. B. Burleigh.

Electrical Engineering Department.
Massachusetts
Institute of Technology.
March 16th, 1906.

Mr. John Campbell,
729 Old South Bldg.,
Boston, Mass.

Dear Sir:—On account of the meeting of our Electrical Engineering Society, of this department, I am unable to be present on March 20th at the informal meeting at the American House.

It is gratifying to know that the subject of illuminating engineering is at last dignified by what promises to be an engineering society of real virility and importance. You may certainly count on my interest and support in the conduct of the organization.

Yours very truly,
(Signed) H. E. Clifford.

Review of the Technical Press

EUROPEAN ITEMS

One of the most interesting and, if accepted in the right spirit, most helpful scions is examining others' opinions of ourselves. Surely every right minded person has often wished for the gift that Burns so poetically craved,—

"To see ourselves as ithers see us."

Especially are these views of others interesting and valuable when coming from those who are widely separated from us by distance, environment and conditions, as under these conditions the estimate is less liable to be warped by personal considerations.

Some ten years ago Prof. Blondel, in alluding to the then common use of bare arcs for street lighting, remarked that "Americans apparently cared as little for the welfare of their eyes as they did for their stomachs." The criticism on the use of bare arcs was well founded, but all good dispeptic Americans will deny the allegation as to the ill treatment of our stomachs.

We are likewise known to be the great exponents of the strenuous life, by reason of which we have admittedly accomplished much in a commercial way; and to offset this credit the European is in the habit of charging us with a lack of appreciation of the esthetic side of life. Thus, the London *Electrical Review* asserts as a truth not subject to dispute, that with us "esthetics have a poor chance, and art has to take a back seat." Nevertheless, it admits that we have outstripped them in the recognition of illumination as a branch of engineering, as evidenced by the organization of the Illuminating Engineering Society, and commends this action to the attention of its own readers. We are glad to reciprocate by stating that the *Review* is the first European technical journal to set forth the claims of the illuminating engineer, which it did in an editorial published in May last, and which we reprinted in our March issue.

ILLUMINATING ENGINEERING.

(Editorial, *Electrical Review*, February 9.)

Last May we referred to an aspect of the question of efficiently lighting enclosed spaces by electricity, and pointed out that there was ample room for an expert on illuminating. Since then the attention of others has been drawn to the fact that electric lighting is often done in a manner utterly regardless of the effect on the eye so long as the floor receives its due quota of candle-power or watts per square foot. Even in America, where it may truly be said that æsthetics have a poor chance in the strenuous life and (to use a colloquialism) art has to take a back seat, it has at length been recognized that a room or hall is not necessarily efficiently lighted by "hitting" lamps promiscuously about on the ceilings. In a paper recently read by Mr. James R. Cravath before the Western Society of Engineers in Chicago, a number of local electrically-lighted halls, etc., were, metaphorically, pulled to pieces. Lantern slides, clearly showing the faulty methods of lighting, were used to assist the vigorous criticisms of the author, who boldly advocated the recognition of illuminating engineers. The function of these experts should be to work together with the architect, in order that the attainment of aristic designs should not be achieved at the expense of illuminating efficiency.

Mr. Cravath, in dealing with public halls, recommended the extensive use of hidden lamps with reflectors; or, where the lamps are on fittings which form part of the artistic design, that the light should be filtered through holophane globes or opal glass saucers. In dealing with private rooms, he instanced the faulty illumination

obtained by fixing bare lamps against a ceiling of oak beams, now so much the fashion amongst those who have the old Dutch mania. He rightly points out that consumers who have such rooms can well pay for more current by using reflected or diffused light. But what about the poorer consumer? Mr. Cravath says that a small living room can be efficiently lighted by an electrolier having two spreading arms with holophane globes for general lighting, and one center light pointing vertically downward with a prismatic glass reflector. He advocates the use of the latter for reading instead of a table lamp, where most of the light is wasted on the table. Such were a few of the suggestions made, but the paper was chiefly of value in regard to the number of examples shown by means of slides. Those who took part in the discussion rather skimmed the subject, as apparently the point of view was a novel one to most engineers. But the agitation, of which this paper was one of the signs, has caused definite action to be taken. Last month in New York there was organized the Illuminating Engineering Society; officers were elected, rules adopted and 89 members enrolled from amongst electrical engineers, gas engineers and architects. Is it not time that something of the sort were done here, where it is no extravagant claim to make that architecture and art are more revered than in the United States?

As regards the methods of lighting available, it seems to us a mistake to rely solely nowadays on the small-bulb incandescent lamp, whose source of light is too small for good diffusive purposes. We now have the large bulb high efficiency lamps, Nernst, Osmium and Tantalum lamps, all of which are much better adapted for diffused or hidden lighting in private houses; whilst for larger rooms and halls the same lamps may be used, with or without miniature or large enclosed arc lamps, to give an economical and soft light, quite unattainable with the ordinary incandescent lamp.

While we are forced to admit that "architecture and art are more revered in England than in the United States," it is doubtful if any such comedy of illumination could be found in the United States or its remotest colonial possession, as is described in the following leter printed in the *Electrical Review* of February 16th. We respectfully commend it to the attention of our municipal ownership friends. Possibly it is only a new phase of the Standard Oil "system."

A correspondent has written us as follows, on the lighting of the city:—"The electric tram system was inaugurated in Belfast some three months ago. Poles in the center of the streets are generally used, and as these are practically invisible after sun-down, oil lamps are attached to each pole. Street lighting is by means of gas —incandescent and flat flame. Royal avenue at night is probably without a parallel in Europe—incandescent gas lamps down the side—twinkling oil lamps down the center; and this in one of the broadest thoroughfares Britain (U. K.) can boast of. Truly, a notable example of municipal enterprise, and a triumph for gas." Our correspondent's letter is a timely one; such triumps are much appreciated by the gas journals, although not by the groping wayfarer.

The condition of the incandescent lamp business in England seems to be in a more or less chaotic condition, both as to quality, and uniformity in methods of testing and rating. Perhaps if they had a "lamp trust" to spend tens of thousands of dollars in standardizing processes of manufacture down to the minutest detail, and maintaining a most rigid system of testing the product from all the factories controlled, it would have less cause for complaint in this direction, and would be ready to admit that the much maligned trust or pool is not always an unmixed evil. Many of the faults which are troubling the English consumers have long since been overcome in this country by reason of the great American tendency to reduce every article of manufacture to standard forms and dimensions where possible. After giving ourselves due credit, however, for better commercial rating and assortment of incandescent lamps, many of the conditions pointed out in the following paper apply with equal force to America. The causes complained of, which are common to a greater or less extent the world over, are only another proof of the urgent need of a more general knowledge of the subject of illumination among consumers, and a greater amount of earnest endeavor on the part of the companies supplying the illuminant to see that the customer receives a fair measure of light for the amount of illuminant paid for.

WASTE IN INCANDESCENT ELECTRIC LIGHTING AND SOME SUGGESTED REMEDIES*

BY GEO. WILKINSON.

(*The Electrician*, February 16.)

Every enterprising station engineer, in order to secure a healthy growth of business against increasing competition, diligently seeks to reduce his cost of production and distribution. Labor-saving appliances—such as fuel and flue gas testing instruments, superheaters, improved forms of steam and electric generators, better methods of conversion and distribution, together with a more intelligent idea as to the effect of load and diversity factors—have done much towards reducing these costs (allowing a corresponding decrease in the tariff charges to consumers), and yet finality in this direction, even with our present methods and knowledge, still lies some distance in the future. The average prices obtained per unit in Great Britain (omitting exclusively tramway undertakings) during 1904 and 1905 were as follows:—

	Year Ending Mar., 1904	Mar., 1905
Limited liability undertakings.	4.26d	4.06d
Municipal undertakings......	3.08d	3.02d

It is when we get beyond the meter fixed on consumers' premises, which marks the boundary of the supply undertakers' authority and jurisdiction, that waste and extravagance take place. This is mainly due to the use of incorrectly-graded and inefficient lamps, and the persisted use of lamps after they have become blackened on the inner surface of the glass bulb. So marked is this lamentable waste, and its effect upon the future of electric lighting is so serious, that it is high time some definitely concerted action was taken by the supply authorities throughout the country to deal effectively with the matter, and to educate every consumer so that he may know how to get efficient electric lighting at a reasonable cost.

Electrical engineers have too long considered themselves simply producers and purveyors of electrical energy, and have not concerned themselves with the problem of turning a minimum amount of electrical energy into a maximum of lighting power, the consequence being that many a user is paying for double the amount of electrical energy for lighting he ought to pay, and not a few lucrative electric light consumers have, regardless of health considerations, gone back to the use of gas.

To show an urgent need for attention on the part of engineers to the points raised, I set forth a few of the many cases which have come under my personal notice during the last few months.

(*a*) *Public Building.*—Eighty 32-cp British-made 100 volt lamps, taking an average of 170 watts each. The light in this case was exceedingly unsatisfactory, owing to drop in pressure, and by putting in 16-cp lamps certified by the Corporation (as hereinafter explained) the light was improved and the current consumption very greatly reduced.

(*b*) *Private House.*—Consumer using 8-cp British-made lamps giving in one case only 2.1-cp at 11 watts per candle, and another 3.2-cp at 8 watts per candle; also one 16-cp giving 8.9-cp at 6.6 watts per candle.

(*c*) Four special 16-cp 200 volt foreign lamps, sent for test, dropped from 16-cp to 7 in less than 100 hours. These might have been used on consumers' premises with disastrous results.

(*d*) *Private House.*—Consumer found to be using 230 volt lamps on a 200 volt circuit.

(*e*) *Private House.*—Consumer found to be using 2½-cp lamps taking 30 watts each, or 12 watts per nominal candle at 200 volts. Actual candle-power given by the lamps was 5 on photometric test.

(*f*) *Shop.*—Nominal 8-cp lamps, giving 5.5-cp and taking 6.6 watts per candle.

The following cases have been given to me by engineers of other electrical undertakings:—

In the public buildings of a large city in Scotland, the British-made lamps from a number of tests made were found to be taking an average of 8.29 watts per mean horizontal candle-power, and 9.14 watts per mean horizontal candle-power in the case of Continental-made lamps.

Investigations made in a leading manufacturing city in Yorkshire show an average of 7.6 watts per mean horizontal candle-power in the case of foreign lamps, and 7.03 watts per mean horizontal candle-power in the case of British-made lamps. Tests made on 8 and 16-cp lamps in stock in the same city, showed a variation of from 2.98 to 5.67 watts per mean horizontal candle.

Investigations in one of the chief cities in Lancashire on new 16-cp lamps held in stock by the Corporation showed a variation of from 3.25 to 8 watts per candle, with a variation in candle-power on standard voltage from 10¼ to 20 candles.

I do not suggest that the lamps in all the above-cited cases are necessarily bad lamps, but they are certainly wrongly graded and marked. These are only a few instances, and I am convinced that in many towns the cost of electric lighting is greatly increased to the consumer, due to errors in the grading and marking of lamps. So far as I can ascertain it appears to be the general practice amongst lamp makers to sell lamps marked with a nom-

* Abstract of a paper read before the Leeds Local Section of the Institution of Electrical Engineers, February 15th.

inal candle-power, but actually giving considerably less than that marked on the bulbs.

SUGGESTED REMEDIES.

Legislative.—Clause No. 18 of the 1882 Electric Lighting Act* should be immediately abolished, and a new clause substituted, giving the electricity supply undertakers right of supervision over the lamps used on their supply mains, and the right to refuse to supply customers using wasteful lamps. In my view this desirable supervision can be exercised without the undertakers taking the lamp trade from the local contractors; such a step on the part of municipalities would be an unwarrantable and unfair interference with the business of private tradesmen in the district.

Local Precaution.—I have, in co-operation with the local contractors in Harrogate, developed a system of control over the lamps used in the supply mains which, while it secures to the Corporation the control referred to, leaves the contractors the benefit of their trade in lamps, and puts no restriction upon them as to what make or class of lamp they supply to their customers. It is desirable that we should have legal powers to compel contractors to supply, exclusively, lamps approved by the supply authority. At present we are able to get a written undertaking only, and depend upon the contractors to abide thereby honorably. In Harrogate such undertaking appears to be quite sufficient at present to effect what we want.

Lamp Specification.—Twelve months ago I drew out a specification (see Appendix), which was issued to all lamp manufacturers supplying lamps to the district, with the intimation that in future lamps would not be certified for use on the Harrogate supply mains which did not come within the specification, both as to candle-power and wattage. The result of the specification was that many grosses of lamps of all makes were returned to the manufacturers from Harrogate. Considerable feeling was manifested on the part of several manufacturers, due to the constant refusal of lamps; now, however, they appear to have settled down to comply with our requirements, and very few lamps which are now sent for certification fail to pass the required tests, and the consumer has already begun to feel the benefit of their improved efficiency. We have numbers of instances where the accounts have decreased since certified lamps were used, and the ultimate result is bound to be an increase of business accruing to the electricity department.

Notices to the Consumers.—A notice is attached to the quarterly account calling the attention of the consumer to the importance of using, exclusively, lamps certified by the supply authority, and warning him against buying lamps from casual travelers.

The question of the efficiency and grading of lamps has recently been taken up by the Municipal Electrical Association, and a more comprehensive and detailed specification than that forth in the appendix has been drawn up; but its issue to the members of the Association is postponed at the request of the Physical Standards Sub-Committee of the Engineering Standards Committee, and the Municipal Electrical Association has elected Mr. C. D. Taite and myself as their representatives on this sub-committee. This committee has gone into the question of lamp efficiency and grading in great detail; have had careful tests carried out by various lamp manufacturers, and have held an all-day conference with the representatives of the manufacturers, and their deliberations are now approaching completion. Doubtless the effect of the Municipal Electrical Association's recommendations, when issued, will be beneficial to all parties concerned, and especially to the consumers. It is difficult, however, to see how the full benefit of these proceedings can be felt until Clause 18 of the 1882 Electric Lighting Act is annulled or modified. It is to be hoped that concerted action will at once be taken by the supply undertakers in this direction.

It is usual in ordering lamps from manufacturers to specify the maximum drop in candle-power allowable after the lamps have been on circuit a stated number of hours at the standard voltage marked upon the lamps. The specification generally fixes a maximum of 20 per cent. drop in candle-power on a 400 or 600 hours' run. In making this test a maximum rise in pressure of 2 per cent. should be allowed, as closer regulation is not obtained on public supply mains.

A difficulty presents itself in the length of time required to verify the drop in candle-power; very few makers or dealers will consent, or can afford to lay large stocks of lamps aside for five or six weeks while drop in candle-power and life tests are being made on sample lamps drawn from each consignment; the consequence is that these important tests are almost entirely neglected, and in the writer's opinion

* 18.—The undertakers shall not be entitled to prescribe any special form of lamp, or burner, to be used by any company or person, or in any way to control or interfere in the manner in which electricity supplied by them under this act, and any license, order or special act is used: Provided always that no local authority, company or person, shall be at liberty to use any form of lamp or burner, or to use the electricity supplied to them for any purposes, or to deal with it in any manner so as to unduly or improperly interfere with the supply of electricity supplied to any other local authority, company or person, by the undertakers, and if any dispute or difference arises between the undertakers and any local authority, company or prson entitled to be supplied with electricity under this act, or any license, order or special act, as to the matters aforesaid, such dispute or difference shall be determined by arbitration.

large numbers of lamps are continually put on circuit which blacken prematurely and bring discredit upon the industry. Experiments which I have made show that a very thin film of deposit on the internal surface of the glass bulb serves to reduce the light by 50 per cent., and a lamp loses two-thirds of its original candle-power before it gets to the condition commonly accepted as "black."

The lamp merchants should rigidly insist upon the makers submitting a percentage of each batch of lamps to an independent and recognised authority for drop in candle-power test; such lamps being selected promiscuously from the bulk; and the maker should furnish a certificate setting forth the results of such tests. A life test is not nearly so important as the drop in candle-power test and lamps which show good results on candle-power after the specified number of hours may generally be accepted as satisfactory on the score of durability.

It is better to use lamps with large glass bulbs, as the internal blackening process is thus spread over a greater area and is therefore thinner, presenting less obstruction to the light. This view is confirmed by the rapidly increasing use of lamps with large spherical bulbs, which do not reveal the blackening process nearly as quickly as the ordinary sized glass bulbs. It is of great practical importance that drop in candle-power tests should be considerably shortened by employing a pressure higher than the standard working pressure, for, say, 150 to 200 hours; this will decrease the expense and inconvenience of keeping back lamps during the weeks at present absorbed in making these tests. Fortunately the time can be shortened to about 150 hours by applying a slightly increased uniform pressure, but this method at present is followed by only one or two British firms; it is, however, common in America, and will doubtless become regulation practice everywhere in the near future.

Equipment of Local Lamp-testing Room.

The large numbers of lamps which are likely to be submitted for test in all local centers where lamp supervision and certification is adopted and the small charge which can be made per lamp (½d. in the case of Harrogate), necessitate expeditious methods, giving reliable results. The writer has experimented in many directions and with many instruments before arriving at a fairly expeditious, reliable and simple method, employing current derived from the ordinary supply mains. The equipment is as follows:—

Wattage Measurements.—The method employed entails the use of a standard voltmeter and a small hand-regulated booster (or sliding resistance in the case of direct currents), by means of which the volts are adjusted to and maintained at the exact pressure marked upon the lamps. After the pressure adjustment is made, each lamp is in turn inserted into a lamp-holder connected with a standarised dead-beat wattmeter, the resultant reading in each case being recorded in ink pencil upon the brass cap of the lamp. They are then placed in light baskets and passed on to the photometer. Any lamps falling outside the specified wattage limits are placed on one side for return as unsatisfactory.

Photometric Measurements.—A grease-spot photometer is employed with a scale graduated directly in candle values, so that the illuminating power of any lamp can be read off at once without calculation of any kind; the scale is an open one, and is graduated up to 70 candles on each side of the zero center line.

In cases where lights of different colors are being prepared, a flicker head is substituted for the ordinary grease-spot head. The light standard is securely clamped on the left of the spot box in such a position on the scale as to give an 8, 16, 32-cp, or other definite illuminating value upon one side of the grease spot. The lamp under test is placed in a lamp-holder upon a moving carriage on the other half of the scale, this holder being rotated at about 200 revs. per min. by means of a small motor and worm gear carried on the moving carriage and controlled by a switch near the operator. A standard voltmeter with illuminated dial is placed immediately over the photometer head, and a small booster adjusted by a screw motion (or sliding resistance in the case of direct currents) is located under the bench carrying the photometer, so that the operator can with facility maintain the exact standard electric pressure.

Standard of Light.—I strongly condemn the general use of pentane or any other flame standard; they are very difficult to manage and vary in illuminating effect, from time to time, according to atmospheric and other conditions. Good pentane is difficult to obtain, still more difficult to keep, and it is expensive. Ordinary incandescent lamps which have been "aged" until their illuminating power becomes stable should be selected and sent to the National Physical Laboratory to be standardised at a declared voltage, and the position in which they are standardised should be carefully marked upon the glass bulb near the cap. These lamps then form reliable standards of reference, from which sub-standards can readily be obtained for use on the photometer by the lamp testing assistant; thus, the original standards being little used, do duty for a long period and seldom require re-standardising.

Lamps which pass are finally stamped upon the glass bulb by means of a rubber stamp and etching fluid, with word "Certified" and the initials or crest of the authority certifying same.

This is to certify that we have tested for candle-power at all angles below the horizontal a 200 volt ¼-ampere Nernst lamp—firstly, when fitted with your diffuser and reflector, and, secondly, fitted with the ordinary alabastrine pear-shaped globe.

The following results were obtained:—

Angle below the horizontal.	Candle-power. With diffuser.	With globe.
0°	19.5	29.0
10°	26.0	31.0
20°	32.5	32.0
30°	38.5	31.0
40°	44.0	29.0
50°	48.5	26.5
60°	52.5	24.0
70°	55.5	21.5
80°	58.5	19.0
90°	60.5	17.0
Mean hemispherical candle-power	38.6	29.0
Watts: 51.2 at 200 volts	——	——
Watts per mean hemispherical candle-power	1.325	1.76

For and on behalf of
Westminster Electrical Testing Laboratories,
(Signed) Lancelot W. Wild,
Chief Electrician.
December 29, 1904.

It will be seen from the above figures that below the angle of 20 deg. from the horizontal, which includes all the useful lighting area, the mean spherical candle-power shows an efficiency of one candle per watt, a result unapproached by any other electric lamp of small candle-power.

Vacuum Tube Lighting.—Some good examples of this system of lighting can be seen operating in business premises along Broadway, New York, notably at the office of the *New York World*, which is illuminated by one tube 86 ft. long, running round the office and fixed beneath the ceiling cornice. Lighting tubes of this class are in operation up to 155 ft. long. They are operated by extra high-pressure alternating current, ranging from 5,000 volts upwards, produced by a transformer enclosed in an earthed metal box; the light produced is soft and agreeable, and is a near imitation of daylight; the intensity of light can be regulated from a faint glow to 20 or more candles per foot of tube, which tubes are about 1¾ in. diameter. The illuminated tube can be looked at without inconvenience to the eye, and it appears as though it were a long cylinder of densely white smoke. The light radiating from such a large surface area gives a very perfect diffusion, and a practically "shadowless light" result. No mercury is used in these tubes, and the makers claim an efficiency as high as 1½ watts per candle, including transformer loss, and state that the life of the tubes is "almost unlimited." Very little information is available about this form of lighting; I cannot find that there are any of these lamps in Great Britain, but the American examples are strikingly effective, and the method is worthy of more attention than it obtains at present. Probably the ultimate form of electric lighting will be by means of incandescent vapor, of which the well-known mercury vapor lamp forms an unsatisfactory and crude example.

This paper is already too long, and I therefore pass over the osmium, tantalum and other new types of electric incandescent lamps, which are still in their experimental stage and unsuitable for the ordinary working pressures of town lighting circuits.

APPENDIX.—Lamp Specification.

Wattage Tests.

2½-cp lamps are not recommended, as they have been found to be very inefficient.

100 Volt Lamps.

A nominal 5-cp lamp will not be certified if the watts consumed are above 26.

A nominal 8-cp lamp will not be certified if the watts consumed are above 34.

A nominal 16-cp lamp will not be certified if the watts consumed are above 66.

A nominal 32-cp lamp will not be certified if the watts consumed are above 130.

200 Volt Lamps.

A nominal 5-cp lamp will not be certified if the watts consumed are above 28.

A nominal 8-cp lamp will not be certified if the watts consumed are above 36.

A nominal 16-cp lamp will not be certified if the watts consumed are above 68.

A nominal 32-cp lamp will not be certified if the watts consumed are above 140.

Candle-Power Tests.

Note.—Lamps are tested in the horizontal plane, and the mean of two readings taken at right angles is the assumed candle-power.

5-cp lamps will not be certified if their actual candle-power is below 4 or above 6.5.

8-cp lamps will not be certified if their actual candle-power is below 7 or above 9, or if the watts consumed per actual candle-power exceed 4 for 100 volt lamps, or 4.25 for 200 volt lamps.

16-cp. lamps will not be certified if their actual candle-power is below 14 or above 18, or if the watts consumed per actual candle-power exceed 3.75 for 100 volt lamps, or 4 for 200 volt lamps.

32-cp lamps will not be certified if their actual candle-power is below 28 or above 36, or if the watts consumed per actual candle-power exceed 3.75 for 100 volt lamps, or 4 for 200 volt lamps.

EFFECTIVE SHOP LIGHTING

By W. A. Toppin.

It is interesting to observe the methods used by others, even if we do not follow them. Most American illuminating engineers would scarcely call the methods of show window lighting as outlined in the following article sufficiently scientific or artistic for use in a modern American store; but they are interesting as showing practices that are presumably acceptable to the English public, where "architecture and art are more revered than in America."

(*Electrical Review,* February 23.)

The effective lighting of shops is really a most important problem. Incandescent gas lighting has made such advances recently that it is a serious competitor to electric lighting. Passing through the streets of several of our large towns, I have been much struck with the fact that some shops using gas are much better lighted than others using electricity. Now, this is not as it should be, for electricity has so many advantages over gas that, if ordinary care is taken, an electrically-lighted shop window leaves nothing to be desired. It is not enough to put up so many incandescent lights inside the shop, and an arc lamp or so outside. The method of lighting should be adapted to the size of the window, and especially to the way the goods are arranged therein.

Certain classes of shops always arrange the goods in a similar manner. For instance, a fruiterer or confectioner generally places his goods in the bottom of the window, as shown in Fig. 1. A most effective form of lighting for this type of shop is obtained by fixing short pendants to the ceiling and using silvered reflectors for the lamps. The light is all thrown vertically downwards, and the articles displayed are illuminated in a most perfect manner.

Tailors and furniture dealers have large windows, and the goods displayed extend back some distance into the shop. This type of shop is shown in Fig. 2; and as the goods are placed in the bottom of the window, arc lighting is most efficient and economical. One enclosed type arc lamp is generally sufficient for each window. In Fig. 3 a shop window is shown with the goods piled up to the top at the back of the window, and some on supports in the front of the window. Drapers', grocers' and stationers' shops are instances of this type. A row of Linolite lamps at the top of the window and plugs at the bottom supplying current to movable lamps fitted with shell reflectors to illuminate the bottom of the window answers admirably.

Where the window is practically full of articles, the method of lighting shown in Fig. 4 is suitable—a couple of small enclosed arc lamps fitted with reflectors, so as to throw all the light on the windows, and either Nernst lamps or the new type of incandescent lamps, *i. e.*, large circular frosted globes, inside the window. Gentlemen's outfitters and jewelers are examples of this type.

An art dealer or photographer's shop should have the means of illumination concealed as much as possible. A suggested method of lighting is shown in Fig. 5. Rows of Linolite lamps at the top and bottom of the window will illuminate pictures placed at the back of the window very well indeed.

The interiors of shops do not require so much care in the choice of lighting. Large and roomy interiors are best lighted by enclosed arc lamps and smaller interiors by Nernst lamps.

FIG. 1.

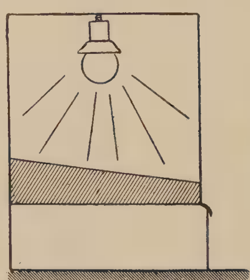


FIG. 2.

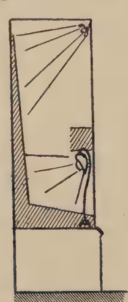


FIG. 3.

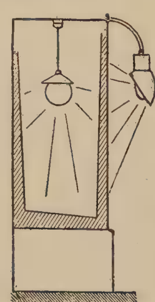


FIG. 4.

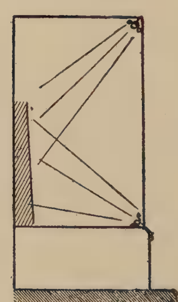


FIG. 5.

Many shops use electric light in the windows and gas inside. This is bad practise from the central station engineer's point of view, as the light is required nearly all day inside the shop, and the window lights are only used when the load on the station is at its heaviest. The engineer thus loses just the load he is in need of, and gets a load he is not particularly anxious for.

PROGRESS IN ELECTRIC LIGHTING

After a comparatively long period of quiescence, the production of light from electricity seems to be again entering upon a transitional period. The signs are numerous and impressive that the next few years will see the passing of the present methods of producing electric lights and the advent of new means far in advance of the old, both in point of efficiency and quality of illumination. Up to the present time black carbon heated to the point of incandescence has been the sole source of electric light. The electric light of the near future will be from either gas in the state of incandescence or from some solids having a vastly higher light-radiating power than amorphous carbon.

(*Electrician,* February 9.)

A paper on this subject was read by Mr. Leon Gaster before the Society of Arts last Wednesday evening, Sir William Preece, K.C.B., F.R.S., in the chair. After a brief introduction, the author described a modern lamp factory, illustrating his remarks with photographs of the Robertson works thrown on the screen. The importance of a constant supply voltage to consumers was then dwelt upon at length, and supply undertakers were recommended to calculate the most economical efficiency, taking into account the life of the lamps and the cost of electrical energy, and then to give free lamp renewals, and so sell light rather than current. The speaker advocated the adoption of a standard specification, as is already proposed by the Engineering Standards Committee, and referred to the need of a new standard unit of light with reliable and convenient secondary standards. In the second part of his paper he described the structure, peculiarities and possibilities of a large number of electric incandescent lamps, arc lamps and vapor lamps, and he had on view a representative collection. These exhibits, most of which were shown in operation, included two novelties not yet on the British market—viz., a 110-volt osmium lamp and a zirconium lamp. The latter is claimed to consume only 1 watt per candle-power, and is at present designed for 37 volts. In the discussion which followed the paper, Dr. R. T. Glazebrook mentioned that he had been engaged for the last two months in considering a standard specification for incandescent lamps, and hoped that the result would be made public before very long. The 10 c. p. pentane lamp was a good standard of light for laboratory work, but was not well suited to ordinary use. Researches in the direction of evolving a satisfactory secondary standard were now being made, however, at the National Physical Laboratory. After a few words by Sir William Preece, who pointed out that the reduction in the price of electric energy had gone hand in hand with the increase in lamp efficiency, the meeting terminated.

A NEW METALLIC FILAMENT LAMP

The Efandem Co., of 67A Shaftesbury avenue, have sent us the following tests on a new metallic filament lamp due to Dr. Hanz Kuzel, of Baden, near Vienna. We are informed that about 100 of these lamps have been manufactured for the purposes of experiment, and that, in order to verify the tests made by Dr. Kuzel and Mr. Joh. Kremenezky, at the latter gentleman's laboratory in Vienna, a number of lamps were also submitted for test to the Electro-Technical Testing Department of the K.K. Technologischen Gewerbe-museum, of Vienna. Our correspondents state that the first two lamps which were submitted to the Institute in the month of August, 1905, for test were taken from a series which had been manufactured on commercial lines, and gave the following results, which were officially certified:—

Series N. Group A.

Lamp No. C1, 32 volts, 13.17 c.p., 0.461 ampere, 1.12 watt per c.p.

Hrs.	Candle-power.	Amperes.	Watt per c.p.	Light difference in per cent.
0	13.17	0.461	1.12	—
98	14.06	0.462	1.05	+ 6.7
218	13.80	0.456	1.05	+ 4.8
314	14.31	0.457	1.02	+ 8.6
434	14.10	0.456	1.03	+ 7.0
578	14.28	0.455	1.02	+ 8.4
753	12.85	0.453	1.13	—10.0
885	12.03	0.451	1.10	— 1.6
1,010	Filament in the loop after 1,010 hours burnt through, rejoined itself, still burning.			
1,029	16.72	0.482	0.992	+26.9
1,167	15.76	0.480	0.975	+19.6
1,339	16.20	0.479	0.945	+22.9
1,468	14.97	0.472	1.002	+13.6

After 1,468 hours burnt out.

Another series of tests gave the following results:

Series U. Group A.

Lamp No. 2, 19 volts, 29 c.p., 1.48 amperes, 0.97 watts per c.p.

Hrs.	Candle-power.	Amperes.	Watt per c.p.	Light difference in per cent.
0	29.0	1.48	0.97	—
503	28.8	1.48	1.02	— 0.7
1,110	26.2	1.49	1.08	— 9.7
1,686	25.2	1.48	1.11	—13.1

After the last figures given above, the current was increased to about 60 volts, thus over-running the lamp, in consequence of which the filament burnt through in the loop. The filament, however, rejoined itself. Lamp still burning.

In another test the lamp was over-run 233 per cent. above its normal voltage without the slightest damage. A second lamp was over-run 201 per cent., the only result being that the normal candle-power of 19½ c.p. after being over-run had risen to 20½ c.p.

Table showing Results of Over-running a Metallic Filament Lamp, normal, 20.2 volts, 19.5 c.p., 0.97 ampere, 1 watt per candle-power.

Volts.	Candle-power.	Amperes.	Watt per c.p.	Light difference in per cent.
20.2	19.5	0.97	1.0	—
25.8	50.0	1.14	0.588	+156.5
32.7	100.0	1.30	0.425	+433.3
34.5	125.0	1.34	0.370	+451.0
39.0	180.0	1.44	0.312	+823.10
40.6	211.0	1.475	0.283	+982.0

It is also announced that these new metallic filament lamps can at present be manufactured for circuits up to 110 volts, but no tests of lamps for this voltage have been sent us. We are also given to understand that "the manufacturing cost of the lamp will be very little different to that of the ordinary carbon-filament lamp universally used up to the present, as the raw materials used in the process of manufacture of the filaments can be obtained in unlimited quantities and are not expensive.

OSMIUM AND TANTALUM

By F. S. Speirs.

(*Electrical Review*, London, February 23.)

The advent of the osmium and tantalum lamps, with efficiencies of considerably less than 2 watts per candle, has invested these rare metals with an importance that could not have been foreseen a short time ago. In both cases has the electric current or the electric furnace been pressed into the service of the filament maker. Pure tantalum was obtained by Bolton, the inventor of the lamp using this metal, by electrolytically reducing a filament made of the tetroxide (which is a solid electrolyte, like a Nernst filament) by means of a strong current in a vacuum. The oxide is really electrolyzed, incredible as it may seem, pure oxygen—which has to be removed to prevent recombination—being given off from the filament until the latter is entirely reduced to the metallic state. In another method potassium tantalofluoride is electrolyzed, and the metallic powder so obtained is heated *in vacuo* in an arc furnace made between electrodes of the material itself ,to remove the oxides and the hydrogen present. Osmium filaments are made by squirting a paste consisting of the finely-divided metal and an organic binding material, and then, after carbonizing, heating electrically in a moist atmosphere to remove the carbon in the form of water gas. At a recent meeting of the Society of Arts, Mr. Gaster exhibited, for the first time, a 1.2 watt per candle lamp containing a filament made of pure zirconium, another of Moissan's electric furnace products.

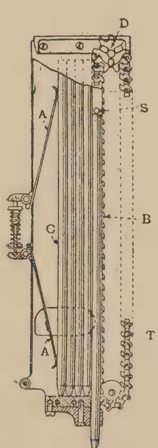


FIG. 1.

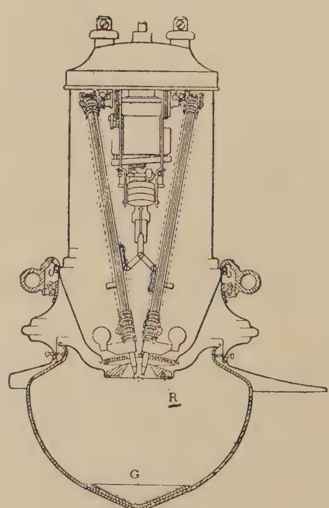


FIG. 2.

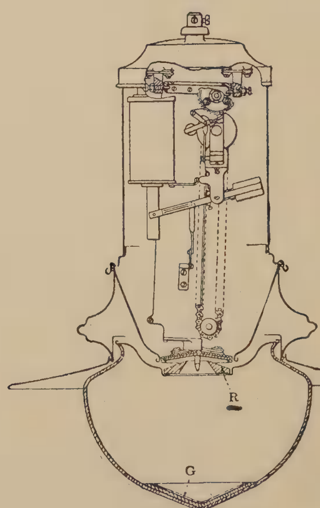


FIG. 3.

MAGAZINE FLAMING ARC LAMP.

MAGAZINE FLAMING ARC LIGHT

The only serious fault charged to the flaming arc lamp at present is the greater amount of care and attention required on account of the short life of the carbons. The lamp described below is a German invention, intended to overcome this fault.

The chief difficulty with which makers and users of flame arc lamps have to contend is the rapid consumption of the carbon, so that the choice hitherto has been between comparatively short burning hours or the employment of abnormally long carbons, which add considerably to the cost of maintenance, as the cost of long straight arc lamp carbons is considerably greater than the equivalent length in shorter pieces. In the Oliver lamp, called by the trade name "Oriflamme," this difficulty is overcome by the use of a "magazine." The lamp can thus hold eight or nine pairs of carbons, each 12 in. long. These are of exceptionally small diameter, but the proportion of the total section taken up by the core is greater than in ordinary flame lamps. It has been found that within certain limits the greater the relative size of the "flame" producing core, the greater the efficiency of the arc, but it is also an unfortunate fact that the greater the proportion of core, the more rapid is the consumption of carbon. Since the carbons are of smaller size, it is possible to use carbon of comparatively poor quality without impairing the steadiness of the arc. The cost of carbons does not exceed 6,09 d per lamp-hour in a 9 ampere lamp. Each pair of carbons burns five hours. The carbons are placed in two flat boxes inclined at an angle of 22 deg. They are put in at the back, and pressed forward by a pair of arms controlled by a spiral spring. Fig. 1 is a sketch of one of the magazines, the arms *AA* pressing against the carbons *C*. The front carbon emerges from the magazine as seen, and is pressed forward by the stud *S*, fixed on a chain *B*. It is this chain that feeds the lamp, being turned by the sprocket wheel *D*. There are two studs, *S* and *T*, on this chain. In the position seen in the sketch the stud *S* is pressing down the carbon as the lamp feeds by the travel of the chain. When this stud reaches the bottom, the carbon is ejected and the next one takes its place, and the second stud *T* has on that moment reached the top of the carbon and presses it down as the chain travels. Figs. 2 and 3, which are sketches showing elevations of the mechanism at right angles to one another, help to indicate the general arrangement. In these figures the reflector *R* is shown, which is designed to prevent the deposit of the products of combustion on the globe of the lamp. It is of porcelain in a copper spinning, and rests on the rim of the globe on three distance pieces. By this arrangement there is an upward draught of air through the hole in the reflector and the products of combustion are deposited above. An ash tray *G* catches the short ends of carbon. It is seen that the angle between the carbons is so small that no blow-out magnet is necessary. The voltage of the arc is 35, so that allowing five more volts for steadying resistance.

SELENIUM AND ITS USES

(*Electrical Review*, London.)

One of the great advantages which electricity has claimed over gas as an illuminant is the readiness with which the light may be turned on and off at any distance from the lamp. Inventors have not been idle, however, in their search for means of giving gas this same advantage; but to turn on gas and light it by means of light itself, would seem an impossible dream of the inventor, had we not become accustomed to "action at a distance" in the now more or less familiar wireless telegraph. The use of light for the transmission of speech is even more wonderful.

The element selenium, which is destined to play so important a part in wireless telephony, has recently been the subject of experiments at the hands of MM. Aichi and Tanakadate, at Tokio, who found that by heating up the selenium to a temperature of 220° C., and then cooling it, they obtained a curve of variation of electrical resistance which did not pass through the origin, and that they could obtain increased conductivity, and a positive temperature coefficient over a large range of temperature, the variation of conductivity being apparently due to a modification of molecular structure.

Selenium was used in 1875 by Werner Siemens in the construction of a selenium photometer, but at that time the metal could only be prepared to be sensitive to the red, orange and yellow rays; recently, however, selenium has been prepared in such a manner that it is extremely sensitive to both radium and Röntgen radiations.

M. Ruhmer, in *L'Eclairage Electrique*, October 14th, 1905, describes a photometer and radiometer for Röntgen rays, in which he makes use of selenium specially prepared for this purpose.

The selenium element is placed in series with a battery and a milliammeter, the

reading of which increases or decreases in a manner exactly analogous to the intensity of the photographic and therapeutic effects. This Röntgen radiometer is the first measuring apparatus which permits of an exact dose of Röntgen rays being given, except by inference, in therapeutic applications.

The effect of light upon the conductivity of selenium has been employed by M. Julius Pintsch in the automatic lighting of gas buoys, and the general arrangement of such an apparatus is diagrammatically shown in Fig. 1, where *d* is the selenium element placed in series with a battery and a relay, the armature of which takes up the position *b* or *c*, depending upon the amount of light falling upon the selenium; the battery current from *f* then passes by way of *b* or *c* through one or other of the two

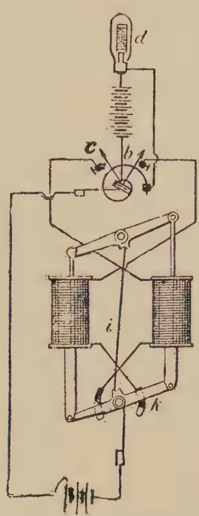


FIG. 1.

solenoids, thus actuating the cock *k*, opening it to light up the buoy at dusk or closing it to extinguish the lamp during daylight.

The consumption of current by the selenium element is so small, that the smallest dry cells will readily last for 12 months; the relay battery *f* is specially constructed to withstand shocks. Such an apparatus has been in uninterrupted use for a considerable time without giving the least trouble.

In Bell's first photophone the solar rays were projected by a mirror on to the silvered membrane of a special speaking trumpet, and thence reflected to the receiving station; as the vibrating membrane is sometimes concave, sometimes convex, the rays are rendered convergent or divergent, and are concentrated on a selenium element placed at the focus of a parabolic mirror at the receiving station, and in series with a telephone. In 1880 Bell and Tainter succeeded in talking over a distance of 200 meters by this method, but using the rays of an arc lamp for the purpose.

Now M. Ruhmer has been able to telephone without wires, with perfect success, over a distance of 15,000 meters.

A microphone is connected in series with a battery and the secondary of a transformer, the primary of the transformer being arranged in series with a direct-current arc placed at the focus of a parabolic mirror; at the receiving end a selenium element is arranged at the focus of another parabolic mirror, and is connected in series with a battery and a telephone.

Variations of intensity of radiation are produced in the arc exactly corresponding with the words spoken into the microphone, and these varying radiations acting upon the selenium reproduce the words in the telephone.

M. Ruhmer, using a 60-cm. searchlight, has recently held communication between Berlin and a clock tower on the Falkenberg, using this apparatus, manufactured for the purpose by the Schuckert Co.

In spite of the absorption of light in transmission, of dispersion, and the fact that the perfectly polished parabolic receiving mirror received only the 100 millionth part of the light from the transmitter, the words spoken into the microphone at Berlin were heard, clear and distinct, in the telephone at the receiving end.

As a larger receiving mirror would gather more rays, it is certain that this method could be operated over much greater distances, such being only limited by the curvature of the earth, since with this method, as distinguished from wireless telegraphy, the two stations must be reciprocally visible.

The results obtained show that the method is of considerable practical importance, and has a distinct sphere of usefulness in naval work, possessing several advantages over wireless telegraphy.

M. Ruhmer has also achieved success in telephoning in both directions, and will publish at a later date the results of his work in this direction.

INVERTED GAS LAMPS*

By Prof. H. Drehschmidt.

In the present competition between gas and electric lighting gas holds its own well. Till lately it was thought that electric lighting would have it in regard to street lighting until it was shown that gas lighting can easily run up to candle-powers of 2,000 and over in forms suitable both for streets and for large buildings.

* Translated from the *Journal for Gasbeleuchtung* September 16, 1905, p. 813, by the *Gas World*, March 3.

Electric lighting did, however, present one advantage over gas lighting. With the latter the light tended upwards, whereas what we want is light mainly sent downwards and the electric arc meets this latter requirement. Gas lamps had therefore to be fitted with reflectors, screens and globes and thus became wanting in elegance. Besides, these things were not very effective. The Berlin street lamp reflectors did not send down more than 6.5 per cent. of the light directed upwards from the lamp. Holophane globes have hardly caught on with the public, being rather difficult to clean and giving a mistaken impression that they reduce the illuminating value. With naked flames, attempts were made—Wenham, Siemens—to construct inverted burners, which marked a great advance but were not wholly successful, because the illumination in a horizontal direction was too feeble and it was only immediately underneath that the lighting was good.

Of late years incandescent gas lighting engineers have also taken to inverted burners in order to secure a better distribution of the light. Many forms have been introduced, but none have made much headway in Germany. Details are difficult to obtain and good authorities are still convinced that there is nothing in the idea. Serious tests have, however, been going on in the laboratory of the Berlin town works for a good while past.

In photometric work we mostly concern ourselves, usually, with the candle-power as measured in a horizontal direction, but with inverted burners we have to study this in different directions and this needs special apparatus. In the Berlin laboratory the apparatus used is that of a Schmidt and Haensch, in which the light is received at various angles under the lamp by a mirror borne by a jointed parallelogram arrangement and is always thrown by that mirror into a horizontal path for purposes of measurement.

The first attempts at making inverted burners were affected by sundry mistakes. In particular, the arrangements designed were too complicated; they had large ungainly chimneys sometimes; it was imagined that the whole of the combustion gases would go through the mantle, which they will not do—they find their way out through the space between the inverted mantle and the burner tube. This space must, therefore, be made ample so as to allow a sufficient outlet for the products of combustion.

It was soon found that it was better to close the mantle entirely below and to connect its upper margin, by means of asbestos fibers, with a ring of metal, or of magnesia, or of other material. These rings had catches of different forms to enable the mantles to be suspended in the burner head. But then there was a great tendency to striking back. Bernt thought this was due to the heating of the burner tube by the products of combustion and that it could be prevented by making this tube of non-conducting material. But it was soon found that it was more to the purpose properly to proportion the burner tube and the diameters of its apertures; for heating the gas mixture and even the primary air was of positive advantage, increasing the lighting power.

Even then, however, even though striking back was overcome, inverted incandescent gas lamps were not yet fitted to gain many friends. The hot gases ascending from them damaged the gas-fittings, and got into the air supply of the lamp itself, thereby occasioning imperfect combustion and a bad smell.

The next step was to put metal screens at some distance above the mantle, in order to lead the products of combustion well away to the circumference, or, in later forms, to one side of the lamp in particular.

Beneath the mantle, to surround and protect it, is a globe like that of an electric incandescent lamp, with holes to admit the secondary air supply. Also hemispherical globes are used, closed beneath, which give the lamp the appearance of an electric incandescent carbon or Nernst lamp; and, in this case, there is usually a chimney, open at each end, surrounding the mantle. In this case the secondary air enters at the rim of the hemispherical bell, descends to the bottom of the chimney and ascends in this. This pattern usually requires an ungainly tall chimney to make sufficient draught; but still it has been found possible to design this pattern artistically.

Inverted gas mantles require careful regulation of the gas consumption and good regulators are best for this. Adjustment of the primary air supply is also required to suit the kind of gas used. The more uniform the pressure of gas, the better. The same may, however, be said of all incandescent gas lamps.

The earliest inverted lamps used a short mantle. The consequence was good lighting below, darkness towards the sides and, generally, an unpleasing effect, as well as a smaller efficiency than that obtained with the longer mantles now in use, which give good lateral illumination. The author used to be of opinion that inverted gas incandescent lighting was good for nothing except direct downward lighting; but the newer lamps, in his own house, have converted him. The older lamps drove him away through their smell and the unevenness of their lighting effect.

In Fig. 1 the curves marked G show, in Hefner units, the candle-power from 90 deg. above the horizontal to 90 deg. below it, produced by an old inverted incandescent burner without special means of taking the products of combustion away

to one side; P, the same with an inverted lamp in which the products were carried off by a suspended screen towards the whole circumference; W, another with a chimney and a hemispherical globe. M shows the result with another burner with preheating of the primary air and with means for leading the products of combustion away to one side. A is the corresponding curve of an ordinary Welsbach burner and B that of the same with a reflector. These curves show remarkable differences in different directions. For better comparison of these differences the candle-power in a horizontal direction is, in this figure, in every case set out as equal to 100. It will be seen how large a proportion of the light from a Welsbach (curve A) is thrown upwards (54.2 per cent. of the whole). With W 63.1 and with M 65.5 per cent. of the light goes downwards and the lateral lighting is quite satisfactory, while quite enough light goes upwards to ensure a pleasant illumination of a room. If reflectors are used, they can be used more advantageously than with ordinary Welsbachs, for they can be fitted on nearer to the mantle. Fig. 2 shows the actual Hefner candle-powers per 3.54 cu. ft. with the same lamps; and it is seen that, with the exception of G, the inverted gas incandescent lamps have the advantage over the ordinary Welsbachs all over the field. For each Hefner candle of mean lower hemispherical intensity, with the best inverted incandescent burners (W and M) the consumptions of gas are 3.85 and 3.81 liter, while with the Welsbach, without reflector, it is 7.1. Inverted gas incandescent burners thus mark a decided step in advance in illumination by gas.

Turning now to a comparison between these new lamps and electric lighting, we get (setting all the horizontal candle-powers equal to 100 as before, for the sake of being better able to compare the distribution of light) the results shown in Fig. 3. In that figure, A is the curve of the ordinary Welsbach lamp, O is that of the osmium lamp, N that of the Nernst lamp, EA that of the electric arc, EI that of the electric incandescent carbon filament lamp, EFA that of the electric flame arc (which sends out no light horizontally, the whole light being directed downwards) and M that of an inverted incandescent gas burner. Of these EI, O and N (with vertical magnesia rod) send about as much light upwards as downwards; and even the electric flame arc, EFA, though it sends all of its light downwards, gives very poor lateral illumination and strongly illuminates only a very limited region below the lamp. It is, therefore, unsuitable for rooms or streets in general, however well it may lend itself to special purposes. The electric arc, EA, is best at about 30 deg. below the horizontal, but is pretty poor immediately beneath. In all these cases the distribution of light by the inverted gas incandescent lamp is materially better.

Fig. 4 shows the results obtained in street lighting. The lamps were 68.9 ft. apart and the burners at a height of 12.1 ft. The curves, W and M, refer to the same lamps as in Figs. 1 and 2 and A and B, as in those figures to ordinary Welsbach lamps without and with reflectors. The curves on the left hand side of Fig. 4 correspond to reduction of the horizontal candle-power to 100 in all cases, as in Fig. 1; those on the right hand side

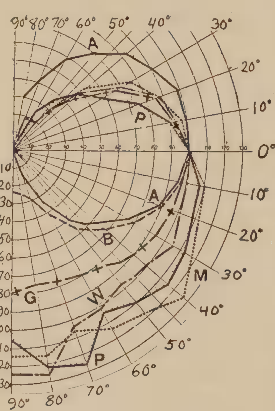


FIG. 1.

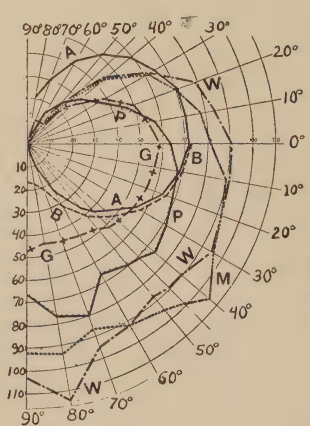


FIG. 2.

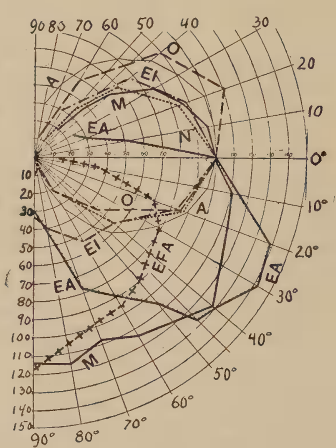


FIG. 3.

to the actual candle-powers. The inverted gas incandescent lamps are superior in all respects; and they are now being practically tested in Berlin street lighting. They do not do well in the old lanterns, however, because with these they cast sharp, black and disconcerting shadows downwards, produced by the metal parts of the lantern. The old Welsbachs, with reflectors, softened these shadows down, so that they did not cause any inconvenience. This difficulty has, however, been quite got over by a new pattern of lantern.

Prejudices against inverted gas incandescent lamps ought now to disappear, for they have, even already, shown themselves capable of rendering great assistance in the struggle with other forms of lighting.

In the course of the discussion which followed, Professor Drehschmidt said that there was no trouble whatever arising from

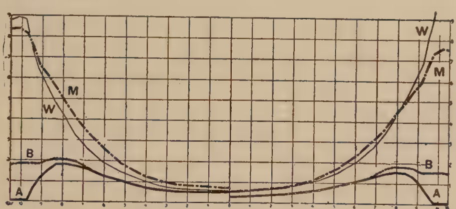


FIG. 4.

production of soot in the newer forms of these inverted lamps. Gas fitters readily learned how to get the best effects from them. Herr Meyer, of Sonderhausen, expressed a hope that the new research station of the association would soon be in a position to issue authoritative data concerning the different patterns on the market. Dr. Bunte said that would come in due time, but the foundation stone was not yet laid; and they ought to be all the more thankful to Professor Drehschmidt, from whom he (Dr. Bunte) had learned much. Herr Schomburg, of Gelsenkirchen, said he had been much troubled by crude forms of inverted incandescent lamps, but at last he had hit upon the right one, with which his consumers had expressed themselves as being extraordinarily pleased, much preferring them to electric lamps.

THE TEMPERATURE OF FLAMES*

By C. McPherson.

In order to attain the maximum temperature, it was evident that rapid and complete combustion must be effected. To do this we must have the highest possible pressure of the molecules engaged in chemical combination. There were various ways in which this could be done. We could add more oxygen, or more hydrogen; we could use higher pressure of gas, or higher pressure of air, or vary the mixture so as to concentrate the flame area. Scientific authorities were still undecided as to which they would adopt to produce a flame of maximum temperature at minimum cost. They were all trying to produce an explosive gaseous mixture that would burn in such a way as to heat a large surface of a mantle consisting of the refractory oxides of certain rare metals to a high temperature of incandescence.

Now, take a few examples of the effect of modifying conditions: Add oxygen to the flame of the bunsen burner and we completed the combustion more rapidly. We also got a flame of much smaller volume when burning the same amount of gas. This proved that the flame had not got to wander so far through the atmosphere to find the necessary oxygen to complete combustion; and from the smaller external surface here occupied, we must have a relatively higher temperature. Add hydrogen instead of oxygen. This must be done at a considerably higher pressure to prevent it from striking back, and we got a flame of actively burning gas. The burning of carburetter water gas gave a small flame volume for the same reason. This was what made the reading of a jet photometer much more unreliable when varying percentages of carburetted water gas were mixed with coal gas. Higher pressure of gas or air would give much the same result. The previous heating or compressing of the gas or air involved similar principles, and the results were much the same—all giving a concentrated flame of higher temperature, owing to the more rapid chemical combination brought about in these various ways. This was exactly what had been done in the Kern and other burners used in connection with the incandescent mantle. It would be observed that the gas passed into an inverted cone, which lessened the skin friction of the primary air, thus enabling a larger volume of air to be admitted through the air holes and to get rapidly mixed with the combustible gas, while, at the same time, the angle at which the slots were cut in the burner head gave a spinning action to the mixture issuing from the burner tips. The inner and outer cones of this burner were split up into a series of blue flames, which rested flat on the burner head. Above this zone the flame was fairly homogeneous.

* From a paper read before the Midland Junior Gas Association. Abstracted in the *Gas World* of March 10th.

AMERICAN ITEMS

THE EFFECT OF ACID FROSTING AND ENCLOSING GLOBES UPON THE LIFE OF INCANDESCENT ELECTRIC LAMPS.—J. R. Cravath and V. R. Lansingh. *Electrical World,* March 17th.

The article gives results of tests carried on under the direction of the authors by the Electrical Testing Laboratories. This is the first authoritative test upon this very important subject that has ever been made, so far as we are aware, and the results obtained are interesting and of the highest importance, not only to the illuminating engineer, but to every one using incandescent electric lamps.

The tests aimed at an answer to the following three important questions:

First: What is the absorption of light due to acid frosting of incandescent electric lamp bulbs?

Second: How does such frosting affect the useful life of the lamp?

Third: How is the useful life of a lamp affected by being placed within a diffusing globe?

The first of these questions has been answered from time to time with widely varying figures. In the tests referred to the loss of life due to the frosting is found to be 9 per cent. It is lower than the figures usually given in such cases. It is usually stated that acid frosting causes an absorption of 15 to 25 per cent., some even giving it as high as 33 1/3 per cent. Of course the degree of absorption by frosting will vary considerably with the method used and the degree of diffusion obtained. This test would seem to show that the general estimates have been too high.

The diffusing globes used were the prismatic globes known as Holophane. The absorption of light by these globes was about 16½ per cent. The lamps used were 16 candle-power lamps running at 3.1 watts per candle at their rated voltage. The tests show that, considering the useful life of a lamp as exhausted when it has fallen to 80 per cent. of its initial candle-power, acid frosting shortens its life by practically 52 per cent. This figure is certainly astonishing, and it is safe to say has never been duly considered by engineers or the public in general. With Holophane globes it was found that the life was reduced by only about 5½ per cent. and that no sensible decrease of life was produced by covering the open end of the globe as tightly as possible with an asbestos disk.

As the authors state, "It is to be regretted that the test did not include ground glass as well as diffusing globes; but judging from the test given in previous articles in these columns on the absorption by ground glass globes, it is probable that a test on these would show very nearly the same results as here obtained." Their conclusion in regard to ground glass globes, however, does not seem entirely justified. If it is the heating effect due to the conversion of the light rays into the heat rays that is the cause of the shortening of the life of the lamp, Holophane globes would have considerably less effect than globes of either frosted or etched glass, for the reason that the globe having its surface formed into more or less deep corrugations, offers a far greater radiating surface for the heat and should therefore remain measurably cooler than frosted or etched glass. This point is one that is worth following up, as is also the effect on the life of a lamp when frosted by sand-blasting instead of acid etching. It is a well-known fact that frosting in this manner produces considerably less absorption than acid etching, and while it does not produce quite as much diffusion as thorough etching, it generally would fulfil the same purpose.

Lamp manufacturers have for some time made an additional charge of about 15 per cent. for frosted bulbs, and this trifling addition to the cost has, curiously enough, been one of the chief factors in restricting the use of frosted lamps. The facts of this test show that the lamp companies have acted directly contrary to their best interests in making this additional charge. As frosted lamps last only half as long, they could well afford to furnish them at the same price for the sake of the increased number required.

ELECTRIC STAGE LIGHTING AT THE NEW STADT THEATER IN NURNBURG.—By Frank C. Perkins. *Electrical Review,* March 10th.

An illustrated article showing the general arrangement of the electric stage lighting equipment of the New Stadt Theater, Nurnburg, Germany. The method consists of incandescent lamps in trough-shaped reflectors and seems to involve no novelties.

THE LIGHTING OF MISCELLANEOUS ROOMS IN RESIDENCES.—J. R. Cravath and V. R. Lansingh. *Electrical World,* March 3rd.

This article is written to supplement two previous articles on Residence Lighting by the same authors, which appeared in previous issues. The chief features of the article are the illustrations, which show different methods of illumination in different rooms, and the methods used are criticised in a general way and suggestions made for improvements.

In referring to one illustration the writers say: "The piano is in an excellent po-

sition with respect to the wall bracket, as light from the wall bracket is thrown on the music from the left of the player." This statement brings out one of the anomalous features of residence lighting as generally laid out by architects, the light-sources being distributed about the room with reference to "symmetry" or some other fancy, and regardless of the position of the furniture. It therefore becomes necessary to adapt the furniture to the light instead of providing the proper illumination for the furnishings, such as tables, pianos, dressers, etc., which require the especial use of light. The article contains many useful suggestions, and points out a number of common errors.

HIGH EFFICIENCY SMALL CARBON LAMPS IN CHICAGO.—*Electrical World,* March 3rd.

A brief article giving the results obtained by the Chicago Edison Company with 5/16 inch carbons used in 3½ ampere enclosed arc lamps. It is stated that with these carbons a consumption of 2.2 watts per candle is obtained, as against 3.4 with ½ inch carbons, an increase of 50 per cent. in light. The company is obtaining a life of about 100 hours from these carbons. The smaller carbons do not blacken the inner globes in a given number of hours as much as do the larger carbons. With the large carbons it was necessary to clean the inner globes every 70 hours, or once between each trimming; but with the smaller carbons this cleaning between trimmings is unnecessary. It is also stated that the light is steadier and has a less excess of blue and violet rays.

INTERIOR ILLUMINATION. — Edwin James Houston. *Electrical Age,* March. The tenth number in a series of articles on Artificial Illumination, and the continuation of an article on the same subject in a previous issue. Illustrated with nine half-tones.

The article deals with the illumination of office buildings, banks, libraries and reading rooms, counting rooms, school rooms and churches, treating the various subjects in a general way, pointing out the faults of old methods and suggesting methods which are considered improvements. The illustrations of interior lighting are all cases in which the Nernst lamp is used. The discussion of the various problems is so general in character as be somewhat vague, lacking the specific analysis which is essential to the treatment of the subject of illumination from an engineering standpoint.

NOTE: The following article, and letter in reply, are reprinted more especially for the purpose of giving readers the beginning of a discussion which will be continued in our next issue.

ILLUMINATION OF THE SUBWAY STATIONS

By E. LEAVENWORTH ELLIOTT.

(*Electrical Review,* August 26, 1905.)

Probably no recent public work has attracted more general attention than the New York subway, and it would seem that every possible phase of this remarkable enterprise that could have any interest for the general public must have received its due amount of publicity; but, after a year's operation, it is found that there are still some minor defects in construction and operation that furnish topics for discussion. The subjects of ventilation and lighting are still burning questions. In considering any complaints on the part of the public, however, it must be borne in mind that the New York citizen has waited many years for the materialization of his dreams of rapid transit, and with his general knowledge of electrical and scientific progress is bound to be satisfied with nothing short of practical perfection. On the other hand, there is no gainsaying the fact that, both as to the illumination of the cars and stations, there is ground for just criticism. To be sure, the illumination in both cases is vastly superior to what would have been considered satisfactory a few years ago; but the people at the present time are so fully educated up to the possibilities of electric lighting, that it is useless to expect them to be satisfied with anything short of the best obtainable, especially in view of the known fact that the operation of the subway is highly profitable; and that the illumination of the cars and stations is not the best obtainable is as readily admitted by those to whose care the operation of the subway has been entrusted as to its patrons; and it is only fair to state that those responsible for its operation are earnestly desirous of making any and all improvements in this line that are practicable. Criticism of the illumination of the stations is more justifiable than of the illumination of the cars, for the reason that the problem is a very much simpler one. The current used in lighting the stations is supplied by an independent set of generators, so that there is no fluctuation produced by the operation of the power used in the motors, and the lights and accessories are not subject to the vibration and jar of those in the cars; in other words, it is a simple problem of lighting a number of rooms from a current generated in a central station. The unsatisfactory results obtained are the more remarkable from the fact that the illumination of the stations was a matter upon which a considerable amount of engineering consideration was given before the installation was made. There are practically but two sources of light to be considered in the problem, *viz.,* the incandescent electric lamp, and the

Nernst lamp. Of these two, the incandescent lamp was very properly selected; it is quite possible, with the best modern types of incandescent lamps and accessories, to obtain at least equally good illumination for a given expenditure of current, while retaining the advantage of its far greater simplicity and reliability.

One peculiarity of the problem was the very low ceilings in the majority of the stations, which rendered it necessary to keep overhead fixtures, accessories, etc.,

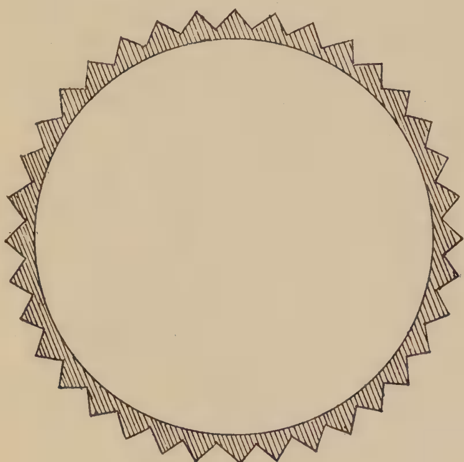


FIG. I.—EXTERIOR SURFACE OF REFLECTOR.

from projecting below the general line of the ceiling, if possible. In these cases the expedient was resorted to of sinking a cove or basin into the ceiling, in which the lamp was placed, and depending upon a reflector placed in this cove to utilize the light radiated in the upper hemisphere. The original intention was to use white enameled iron for these reflectors, but white coated prismatic glass reflectors were finally chosen instead. In the stations where the ceilings are higher, single-light brackets are attached to the supporting columns, the brackets being fitted with a device intended to supplant the Meridian lamp. The device consists of a prismatic glass reflector, fitted with a blown glass cup, frosted on the inside, covering the lamp. The idea of this combination was to make possible the use of the ordinary commercial thirty-two-candle-power lamp in place of the more expensive five-inch Meridian lamp.

The use of prismatic glass reflectors in the two different methods described has brought out some of the queer vagaries that seem to be inseparable from the theory and practice of artificial lighting. These are set forth at length in an article on the lighting of the subway which appeared in a recent number of a technical journal. In this article we are seriously informed of the astounding fact, that the efficiency of a prism reflector may be increased some twenty per cent. by painting or enameling it white on the prism surface. By this expedient, we are informed, it is possible to obtain the reflecting power of both prism glass and white surfaces.

The attempt to increase the efficiency of a prism glass reflector by painting it would pass as an ordinary blunder, due to lack of knowledge of the laws of optics by which prism glass acts, had it been made by the ordinary electrician or mechanic; but the most remarkable feature of the present case is, that this proposition, which has been put into actúal practice, comes from an engineer whose work in the past has justly earned for him an international reputation. That such a "bull," therefore, should have been made by such an engineer, can be ascribed only to one of those peculiar lapses of judgment which the best of scientists sometimes fall into.

Since prismatic reflectors are now in very general use, it may be worth while to explain briefly the theory upon which the reflective power of prisms depends. The prismatic reflector makes use of a phenomenon in optics known as "total reflection." It is called "total" reflection because it is the only case in which reflection takes place without absorption. Reflection of this kind occurs only at the surface of a rare medium, commonly air, in contact with a substance of greater density, such as glass or water. In order to utilize this principle in a reflector, the glass on the exterior surface is formed into right-angle prisms, as shown in cross-section in Fig. 1. The light from the source placed within, striking the inner surface of the glass in a practically perpendicular direction, passes through without refraction to the outer surface. At this point, meeting the surface of the air, it is reflected backward into the glass, its direction following the general law of reflection, as shown in Fig. 2, in which AB represents a ray of light from the source and *m n*, the surface of the glass. The ray is then reflected at B, to the point C on the surface *m o*. At this point it is again reflected in the direction CD, in a direction parallel with its original course. Now, the fact that the ray is reflected at B and C is due entirely to the difference in density, or, more strictly speaking, the difference in the index of refraction of the glass and the air. Let the surface of glass be covered with any transparent medium of approximately the same density, or index of refraction, and no reflection will take place; as can be readily demonstrated by immersing a prism reflector in water. This fact is taken advantage of in the construction of compound lenses, in which, in order to avoid the reflection of light at the surfaces of the two lenses, a layer of fir balsam is placed between the glass, which, making optical contact with the two surfaces, cements them

together, so that the light passes through as in a single piece of glass. If, therefore, any liquid is brought in contact with the surfaces of the prisms, the reflection of the light, in accordance with this principle, is at once entirely prevented. By applying any substance in the form of powder, mixed with liquid, reflection on the principle explained ceases, and whatever reflection

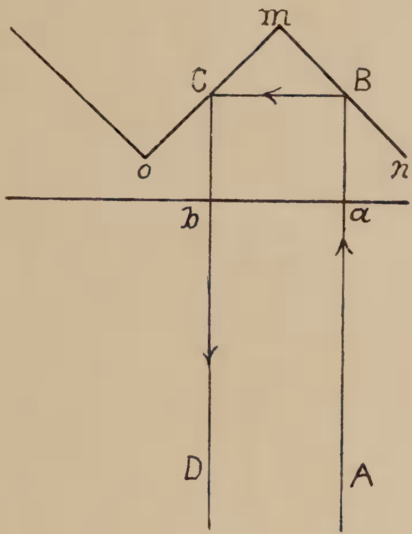


FIG. 2.—GENERAL LAW OF REFLECTION.

takes place results from the diffused reflection from the substance mixed with the liquid.

That there is no special dispensation whereby the laws of optics are suspended in the case of the prismatic reflector, is demonstrated by the simple experiment of painting such a reflector on either side, and determining the curve of intensity of the light reflected. The results of such an experiment are given in Fig. 3, in which curve No. 1 shows the distribution of a prismatic reflector enameled white on the outside, and curve No. 2 the same reflector coated with white paint on the inside. If a reflector is to be painted or enameled at all, it is clear from these results that the paint should be put on the inside; as in this case the absorption of the light in passing in and out of the glass is avoided.

A white enameled prismatic reflector has the same sort of reflecting surface as opal glass, *i. e.,* white particles imbedded in a solid transparent medium; and, as would be expected, give practically the same distribution, as shown by the curves in Fig. 4, in which curve No. 1 shows the distribution of the enameled, and No. 2, of the opal glass reflector, of similar size and shape.

In setting forth the alleged advantages of the painting of reflectors, the writer of the article mentioned states that they give a broader distribution, *i. e.,* a greater intensity at wider angles from the vertical, than the unpainted reflector. This is a half truth, and such truths are sometimes more misleading than absolute untruths. The half of the truth is in the fact that a reflector which tends to concentrate the light into a more or less nearly parallel beam will naturally send out more of the light sidewise when painted white, as it then becomes a diffuse reflector, and all diffuse reflectors give approximately the same distribution. Where the statement ceases to be true is in the statement that "if it is impossible to secure a wide-angled distribution by means of prismatic reflectors alone." A prismatic reflector acts in the same manner as if its surface were a speculum or mirror; consequently the distribution of the reflected light can be varied at will by properly shaping the general contour of the reflecting surface. Thus, if the surface be of parabolic shape, with the light source more or less nearly at the focus, the reflected light will be strongly concentrated into the vertical direction; that is, will become a more or less nearly parallel beam, as in the case of a searchlight. By changing the contour, however, it is possible to produce the maximum intensity at any desired angle between the horizontal and the vertical. In brief: with a diffuse reflecting surface only a very limited variation in the distribution can be obtained, while with specular reflecting surfaces practically any desired distribution is possible.

To return now to the discussion of the

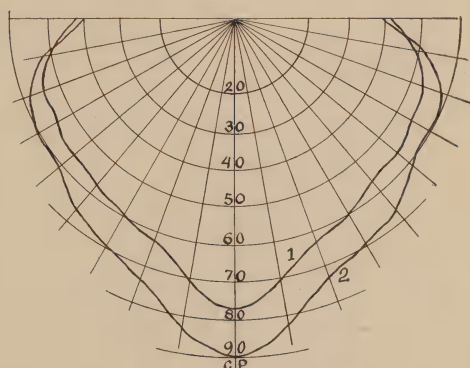


FIG. 3.—LIGHT DISTRIBUTION WITH PAINTED PRISMATIC REFLECTORS.

original problem: that the subway stations are insufficiently illuminated is an undeniable fact. In entering a station from the bright daylight of the street the contrast is so great as to give one the idea of entering a dimly lighted cellar; and by night there is a general appearance of gloom, especially in contrast with the comparative-

ly brilliantly lighted cars. This defective illumination is due to two causes: first, insufficient total quantity of light provided; and second, inefficient means of utilizing

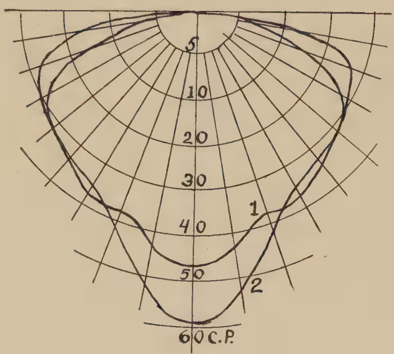


FIG. 4.—LIGHT DISTRIBUTION WITH ENAMELED AND OPAL REFLECTORS.

the light that is produced. The former defect is readily corrected by substituting lamps of higher candle-power than those now in use; but as this would entail additional expense, the remedy of seeking a more efficient utilization of the light now produced should be first considered. Three methods are now made use of for distributing and diffusing the light: first, plain glass globes and sand-blasted on the inside; second, a small prismatic reflector with ground class cup placed within so as to cover the end of the lamp; third, a white enameled prismatic reflector with a similar ground glass cup covering the lamp. To diffuse the light of an incandescent electric lamp is generally a material benefit to the resulting illumination, but in the present case there is less demand for such diffusion than in almost any other case of interior lighting, for the reason that, with the exception of the employees, the stations are only occupied for a few minutes at any one time by the same person; and it is furthermore not necessary to provide illumination for reading or other careful eye work. We may remark while on this subject that in the cars, while reading is the general practice, and where the occupants may remain for three-fourths of an hour, the lamps are left bare without any attempt whatever at diffusion. As between cars and stations, therefore, the requirements in this regard have been exactly reversed.

The practical guide for the illumination in the stations is the intensity of light on the platforms. Light on the ceilings is of little consequence. In determining the relative efficiencies of different methods of illu-

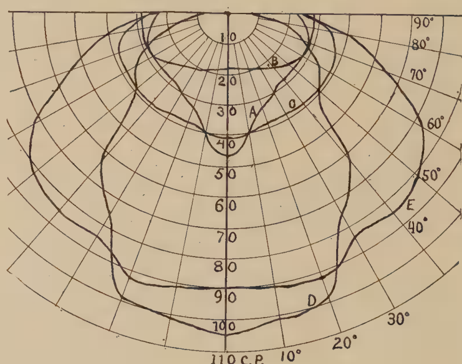


FIG. 5.—DISTRIBUTION CURVES.

mination, therefore, the light on a horizontal plane represented by the platforms may be taken as the test. The light-sources are placed at the distance of practically fifteen feet apart, and nine feet above the floor. A ray of light emitted from one source and

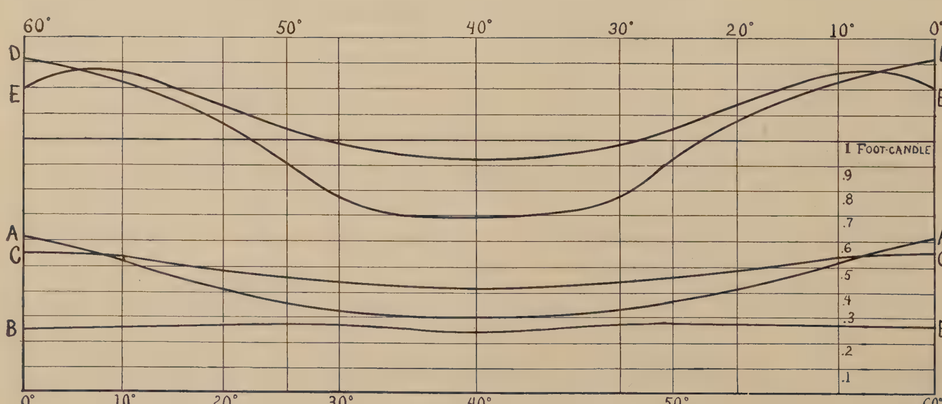


FIG. 6.—ROUSSEAU CURVES.

falling directly below the adjacent source makes an angle of practically sixty degrees with the vertical; and it is only the light falling within this angle that is of practical use in illumination. In Fig. 5 are given the curves of distribution of three devices now in use and of two others which are suggested as improvements. Curve A is the small prismatic reflector with ground cup; B the plain ground glass globe; C a white enameled prismatic reflector with tne ground glass cup; D pagoda prismatic reflector, and E pagoda reflector with fifty-candle-power lamp. In all of these except E, a thirty-two-candle-power lamp was used, as employed in the subway. In Fig. 6 are given the Rousseau curves showing the comparative total quantities of light given out in the lower hemisphere. As before stated the light emitted within an angle of sixty degrees is the important thing to be considered, and it is worthy of remark here, in view of the superiority claimed for the white enameled prismatic reflector, namely, its wider angle of distribution, that the plain prismatic reflector of the same diameter, shown in curve D, gives sixty-six per cent. more light within an angle of sixty degrees from the vertical than the enameled prismatic reflector.

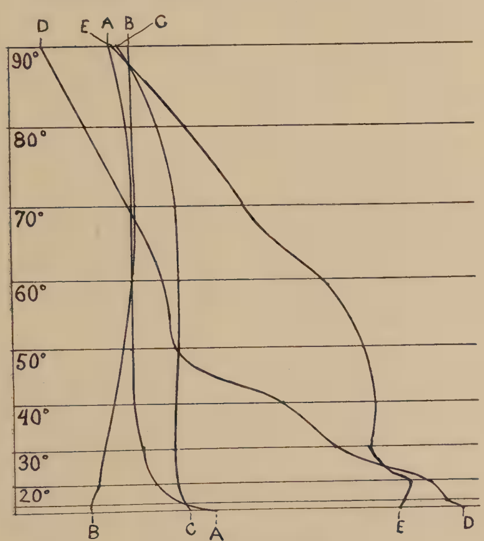


FIG. 7.—ILLUMINATION OF PLATFORMS.

Fig. 7 shows the curves representing the illumination on the horizontal plane of the platforms in a line between the bases of the vertical rays from two adjacent lamps. These curves bring out several interesting points. Beginning at the lower point B, which is that of the ground glass globe, the device most generally used, the illumination is nowhere up to 3/10 foot-candle intensity, and the illumination from the small prismatic reflector and ground glass cup exceeds 6/10 foot-candle only within a very small space directly underneath, and falls to 3/10 between the lamps. With a pagoda reflector, curve B, the maximum intensity is over 1.3 foot-candles, and the minimum intensity slightly less than 7/10. With a fifty-candle-power lamp and prismatic reflector shown by curve E, a minimum of over 9/10 and a maximum of over 1.2 would be obtained. With a pagoda reflector and clear lamp more than twice the illumination on the platforms would be obtained as is given by the present methods, and the improvements thus made would give a fairly satisfactory illumination.

Thus, as was pointed out before in the case of car lighting, the faults of the present system could be largely if not entirely overcome by the selection and use of the proper accessories without increasing or changing the present light-sources.

THE ILLUMINATION OF THE SUBWAY STATIONS

To the Editor of the Electrical Review:

In your issue of August 26 an article by Mr. E. Leavenworth Elliott, entitled "The Illumination of the Subway Stations," criticises the method adopted. The writer is in no wise responsible for the arrangement of the lighting of the subway, except in the design of the diffusing reflectors referred to in this article. The value of this reflector is seriously questioned by Mr. Elliott, but since this matter is dealt with fully on another page of this issue, it need not be taken up here. The engineers in charge of the lighting of the subway gave the fullest consideration to all available sources of light, with such adjuncts as appeared to be suitable. From these, after exhaustive tests, which included the Pagoda reflectors, selection was made to fulfil, in the best manner possible, the service of the public.

In this examination the following points were considered: first, satisfactory illumination; second, avoidance of injurious conditions to the eyes; third, reasonable economy.

In the article referred to above, the following statement is made: " . . . but in the present case there is less demand for such diffusion than in almost any other case of interior lighting, for the reason that with the exception of the employees the stations are only occupied for a few minutes by the same persons; and it is furthermore unnecessary to provide illumination for reading or other careful work."

With this as a premise, the present means of lighting is depreciated, and various changes are suggested which would result in uncomfortable intrinsic brightness. Yet it would seem that, granting this premise, the manner of lighting the subway is entirely justified, even when based on Mr. Elliott's curves. The curves presented in

these figures consider in much detail the illumination of the *floor* of the stations, but in order to secure this desired illumination, the eyes of the passengers would necessarily suffer from the intrinsic brightness of the source suggested, when viewed from the average height of the eyes. This is assumed to be five feet three inches from the floor. It is obviously desirable to secure sufficient light, but it is not clear why more than a sufficing light should be provided. All that is required at the plane of the floor is for the passengers to see their way clearly. They should, however, be enabled to read newspapers comfortably, and therefore it was determined to provide sufficing illumination at the plane at which the average reader is likely to hold a newspaper. This was taken to be four feet six inches from the floor, and all arrangements were based upon this.

An examination of the Rousseau curves of the reflectors now in the subway, and the one propesed by Mr. Elliott (all given in Fig. 6 of this article), indicates the following (see Fig. 1, page 697): the curve for the ground-glass balls shows a well-distributed light, sufficing for general illumination, but not for reading except directly under each ball. The curve for the bell-shaped reflectors shows sufficient light for comfort for general illumination, this being the purpose for which they were intended. This gives excellent distribution, making a good general illumination, which is all they are called upon to do.

The curve for the prismed-glass diffusing reflectors shows a remarkably uniform distribution, securing directly beneath the light at the plane for reading more than two candle-feet. It gives a little less than one candle-foot four feet away, even if not reenforced by other lamps, yet here they receive not less than one-third candle-foot re-enforcement from the three adjacent lamps. At eleven feet away from the lamp toward the center of each group of four lamps, at the plane adopted for reading, the four lamps give each 0.105 candle-foot, making here available about one-half candle-foot. This may be considered the minimum lighting in the subway where the diffusing reflectors are used.

It is true that the so-called Pagoda reflector with a thirty-two-candle-power lamp gives up to forty-eight degrees higher intensity than the arrangement with the diffusing reflector; but beyond this it becomes rapidly less, while the curve for the diffusing reflector shows a well-sustained, equable illumination, sufficing, but not uncomfortably brilliant. It is probably correct that the Pagoda reflector gives sixty-six per cent. more light in the sixty-degree zone, but, as a matter of fact, it falls below the subway reflector at forty-eight degrees, and thence rapidly to about six candle-power at ninety degrees. To have too much light at one point, and not enough at another, is not good lighting. The curve for the prismed-glass diffusing reflector shows, on the other hand, a maintained, although moderate, curve throughout from zero to ninety degrees. Such distribution is of value where general illumination is sought for, rather than the lighting of spots.

Illuminating engineers will insist that uniform lighting is preferable to a method of extremes. Further, exposed sources of high intensity are more injurious to the eyes than insufficient lighting.

A lamp of small candle-power, but of clear glass, will give the impression of higher candle-power than a lamp giving more light, but covered with a ground-glass bulb. When, however, an attempt is made to read thereby, it will be quickly discovered that the less intrinsically brilliant source with the ground-glass bulb or cover will enable one to read comfortably at the longer distance.

To maintain illumination throughout, up to a given desirable minimum with the clear prismatic-glass reflectors, requires a larger number of lamps to be used. This involves limited areas that will be uncomfortable and injurious to the eyes, owing to the too great intrinsic brilliancy which is given by this type of reflector. Further, should any lamp be accidentally extinguished, there will be greater inconvenience from alternate over-brilliant and dark areas. This effect is minimized where diffusing reflectors and globes are used, as all the adjacent lamps will contribute to lighting the space otherwise unlighted.

The Pagoda reflector gives a mean value of 40.3 candle-power for the seventy-five-degree zone, while the subway diffusing reflector gives only 36.2 candle-power. But the engineers of the subway, in their determination to protect the eyes of the public, have deliberately sacrificed ten per cent. of the available light by covering the lamps with ground-glass balls. Without the ground-glass covers the illumination secured from the diffusing reflectors would have been at least equal to that of the Pagoda reflector, with, in addition, a superior distribution.

Ordinarily, frosted incandescent lamps would be used to avoid the intrinsic brightness of lamps with clear glass bulbs. The original cost of frosted lamps is twenty per cent. greater than of clear glass. They give, at first, a reduced light of ten per cent. and further rapidly deteriorate because of the accretion of dust, etc., on the frosting on the outside of the bulbs. Their lives are very considerably less than lamps with clear bulbs. Therefore, both as a matter of economy and efficiency, clear glass lamps were adopted, covered by removable bulbs or domes frosted on the inside.

Mr. Allard, a French authority, estimates brilliant sunlight at the earth's surface to

be equivalent to 5,350 candle-feet. Necessarily, in passing from such an illumination on the street to the subway, an impression den contract; but if it were attempted to secure the equivalent of only four candle-feet (which is the minimum estimated room daylight illumination), it would be necessary to have lights of high intensity and great intrinsic brilliancy, with suitable appliances for diffusing and softening the light. This is entirely possible, but would not be economical; nor does it appear called for. Further, if, as proposed, the illumination of the *floor* of the stations is accepted as the standard, to secure the minimum equivalent of room daylight it would be necessary to install lights of 324 candle-power in the ceilings at nine feet height. Such an arrangement would give an illumination of twenty-three candle-feet at the height of the average eyes. Anything less than this might still give an impression of relative darkness to those coming from the street, and even this would not suffice to remove such impressions on a sunny day. The complaint that the subway gives the impression that it is darker than the streets is not removable within economic limits, nor is there any valid reason for attempting it. In fact, it would be a bold illuminating engineer who would advocate this, or even the seven candle-feet at five feet three inches height from the floor, which would result if the suggestion presented in Mr. Elliott's criticism were adopted.

The illumination in the subway stations must not be considered final, for consideration is constantly being given to this matter. When a method is found which reasonably satisfies the conditions of comfort, efficiency and economy better than does the present system, action will probably be taken by the authorities. It is not dogmatically contended that the illumination in the subway stations is sufficient. If more light is really required, it appears that some additional lamps should be installed, of moderate power, rather than to replace the present system by lamps, reflectors, etc., giving the objectionable intrinsic brightness as proposed by Mr.. Elliott. It is suggested that one additional lamp and reflector placed in the midst of each group of four would accomplish all that is required.

E. L. Zalinski,
Major U. S. Army (Retired).

THE DIFFUSING REFLECTOR

By E. L. Zalinski.

(*Electrical Review*, November 4, 1905.)

In an article on the lighting of the New York subway, contributed to the issue of the *Electrical Review* for August 26, Mr. E. Leavenworth Elliott criticises the use of a prismed reflector, stating that the theory of the device is incorrect, and giving measurements, etc., to substantiate his point. This reflector was described in an article contributed to the *Electrical Age* of May 25, and the data given there for the gain secured by adding a diffusing coating to a prismed-glass reflector are vouched for by the report of measurements made by the Electrical Testing Laboratories, of New York City. Since, however, this device has been brought into question, it seems desirable that further data concerning its performance should be made public. The information given below is based on measurements made chiefly at the Electrical Testing Laboratories.

In Mr. Elliott's article, surprise is expressed that such a "bull" should be made as to attempt to increase the efficiency of a prismed-glass reflector by painting it or enameling it white on the prismed side. This is quasi-acknowledgment that the results sought for might be accomplished by having the coating on the inside of the reflector; but I shall first endeavor to prove that good results are obtainable by placing the coating on the prismed side, and will then show that they may also be obtained by coatings on the inside, but without any great advantage.

In order to prove that an increase in the efficiency of twenty per cent.—which is characterized as a "blunder"—is obtainable, I shall cite a series of measurements where the gains are as high as twenty-seven per cent., and where a paint coating gives a gain of 20.4 per cent. In the case of the subway lighting, which was under consideration, the claim is made for a zone of seventy-five degrees, and this should be as allowable as the claims covering only a sixty-degree zone for the Pagoda reflectors. In one series of measurements which follows, the dimensions and shapes of the reflectors used are the same. The results show that the claims are based on exact measurements, and not on "half truths" or guesses.

Mr. Elliott discusses in his article the well-known principles governing prismatic reflectors, but these principles hold only in the single case where the source of light is a point, which is not the case when the source is an incandescent lamp. Moreover, various points militating against the securing of an ideal efficiency are ignored. Among these are the fact that the reflected ray cannot equal the incident ray in any case, since each reflection must cause some loss of light. Further, the reflecting surfaces of the prism are not perfect, and the light passes through the glass twice, and must lose by absorption. For these reasons the result is less than 100 per cent. effective total reflection. Considerable light which is not lost by absorption passes through the prisms unreflected.

(*To be continued.*)

Miscellaneous News

BUFFALO, N. Y.—Mayor Adam has filed with the Gas and Electricity Commission a complaint against the Buffalo Natural Gas and Fuel Company, which supplies natural gas to private consumers in Buffalo and to the city. The complaint alleges that the company controls a monopoly of the natural gas situation in Buffalo, and complains of the purity, pressure, and illuminating power of the gas, and of the excessive and exorbitant prices charged. Private consumers pay 30 cents net per thousand and the city 27 cents.

An aldermanic committee has been appointed to confer with the General Electric Company to endeavor to obtain a general reduction in the prices of light and power.

A mass meeting of citizens has been held under the auspices of the Referendum League for the purpose of furthering the project of establishing a municipal lighting plant. The meeting was addressed by Mr. Carroll, who has had charge of the city municipal electric lighting plant of Chicago, and by Mr. Frank C. Perkins, who spoke on municipally owned public service plants in Europe.

BRIDGEPORT, CONN.—Extensive additions are being made by the Bryant Electric Company, and also by Harvey Hubbell, Inc., both manufacturers of electric lamp sockets and specialties. The United Electric Company is also largely increasing its power house. There is a lively competition on among a number of light companies for furnishing and lighting 500 incandescent gas lamps in the streets.

CHICAGO, ILL.—The People's Gas Light and Coke Company have purchased a 300-acre tract in the southwest part of the city, on which they will erect one of the largest gas plants in the world. Five million dollars will be expended at the beginning, which will be largely increased by additions and improvements. The initial capacity will be 20,000,000 cubic feet per day.

CHICO, CAL.—The city authorities are seeking to reduce the bills of the Pacific Gas and Electric Company, alleging a lack of service.

DENVER, COLO.—The Denver Municipal Ownership League is waging a campaign for the municipal ownership of the gas and electric lighting plants of the city. This complaint is being vigorously opposed by Mr. H. L. Doherty, who controls the present company. The present price of gas is $1.35, and demand is being made for reduction to 9 cents, and 20 per cent. reduction on electric lighting. The League proposes that the city shall acquire the plants now in operation. They have some 15,000 names on their petition to the city authorities.

DETROIT, MICH.—The management of the Detroit City Gas Company has come to an agreement with the Councilmanic Committee on Franchises, by which the price of gas is reduced to 80 cents, with a minimum of 25 cents per month for meter rent.

FALL RIVER, MASS.—Mr. W. M. Crowell will shortly establish an acetylene gas plant in Pottersville for the accommodation of the numerous dwelling houses that have recently been built in that vicinity, especially on Washington avenue. Nearly all of the new houses are being piped for gas in anticipation of this much-desired convenience.

HAMILTON, ONT.—The Hamilton Light and Equipment Company has been organized with a capital of $40,000. This company proposes manufacturing a new electric lamp, said to be very much superior to any ever before invented, and will have its factory and head offices here.

LOUISVILLE, KY.—The General Council has passed an ordinance granting a franchise for a new lighting company, which will compete with the present Louisville Lighting Company. It is claimed that the present company is charging the city unnecessarily righ rates for electric street lighting.

LEAVENWORTH, KAN.—The Leavenworth Light and Heating Company has reduced the price of both natural gas and electricity, the reduction in the latter being equivalent to about 25 per cent. from its former rates. This reduction carries out a is given of insufficient lighting by the sudpromise made by the company two years ago that cheaper rates would be made as soon as conditions would warrant it.

LOS ANGELES, CAL.—The *Examiner* gives the following pertinent information: "Gas Man's Report Puzzles Council. Inspector Presents String of Figures but no Information." In the report thus complained of the Gas Meter Inspector gives the results of a number of tests, showing the candle-power and heat units of the gas supplied by the Los Angeles Gas Company, the figures showing that the gas is a trifle over 18 candle-power, and an average of about 620 heat units. The article concludes with the statement that these figures "mean lit-

tle or nothing to the councilmen." This is one of the many cases in which politicians and public officials investigate matters about which they know nothing, and then complain of the results.

NEW YORK CITY, N. Y.—Deputy Water Commissioner Cozier is seeking an appropriation of $75,000 to begin the work of modernizing the gas street lighting of the Borough of Brooklyn. Mr. Cozier plans to replace the 6,000 open flame lamps with mantle lamps, such as are now used in Manhattan and the Bronx. It is planned for the city to erect its own lamps, by which it will effect a saving, he claims, of $175,000 a year. He says: "The new system will be operated and managed by the city officials. It will mark the introduction of the biggest improvements towards municipal ownership."

PHILADELPHIA, PA.—The Philadelphia Electric Company has made a reduction in the price of current for domestic lighting, amounting to discounts of 10, 20 and 33 1-3 per cent. The purpose of this reduction as stated by the company, is to encourage a greater consumption of current. When bids were opened for the electric lighting of the city streets in 1907 the Philadelphia Electric Company was found to be the only bidder. It asked the same prices as were being paid for electric lighting of the city for the current year.

A competing company, to be known as the Commonwealth Electric Company, is seeking a franchise from the city with fair prospects of coming to an agreement with the Mayor and Councils. There is also some talk of a municipal plant.

PITTSBURG, PA.—A resolution has been adopted by the City Council seeking to secure lower rates for the electric lighting of the streets, and an attemnt is being made to repeal the franchise of the Duquesne Light Company, a would-be competitor of the Allegheny County Light Company.

POTSDAM, N. Y.—A year ago the Board of Trustees of the village submitted a proposition to the voters for the erection of a municipal electric lighting plant, which was carried by an overwhelming vote. Since then a State law has been passed that no municipality shall build, maintain, and operate any works or system for the manufacturing and supplying of gas or electricity for lighting purpose without a certificate of authority granted by the Commission. As the plant authorized by the trustees was not completed before the passage of this act, the Potsdam Electric Company is now contesting the legality of this action and seeking to restrain the trustees from completing the plant.

ROCHESTER, N. Y.—The *Democrat and Chronicle* says: No one in Rochester ever heard before the Cutler administration of a "gas test" made officially to ascertain if the municipality and citizens were being supplied with the quality of illuminant for which they were paying. It was some time ago, however, that City Engineer Fisher was authorized to procure apparatus for making such tests, which he did at an expense of about $600, and tests are now regularly made, and the results thereof reported to Mayor Cutler.

SYRACUSE, N. Y.—The State Gas and Electricity Commission is investigating the Syracuse Lighting Company. The investigation is being conducted on a very elaborate scale, with counsel and experts on both sides, and the report will be a voluminous one. The city complains that the lighting company has an absolute monopoly on both gas and electric lighting, and that unreasonable rates are being charged. It is understood that Mayor Fobes demanded the following rates of the company: gas to consumers, 90 cents; incandescent electric lamps to private consumers, 6 cents per kw.; incandescent electric lamps to city, 5 cents per kw.; electric arc lights, $70 per year. The rates now charged by the Syracuse Lighting Company are: gas, $1.00; incandescent lamps to private consumers, 10 cents per kw.; incandescent lamps to city, 8 cents per kw.; arc lamps, $85.77 per year.

SALEM, MASS.—A new plan for generating electricity is being worked up in Salem. Certain men have become interested in a new process of making electricity, which is claimed to be chceaper than any present process in common use. They have been talking with business men about erecting small power plants in various sections of the city, and of supplying power to the shops, stores and houses in the vicinity. It is claimed that these new generators may be used wherever a large amount of steam or heat is generated for power for a factory or heat for a store.

SAN DIEGO, CAL.—A special street lighting fund has been provided by private subscribers. As a result, arc lights were installed on a certain street, and after a two weeks' test the result is pronounced unsatisfactory by most of the subscribers. They now propose to put in incandescent lights in place of the arcs.

STERLING, ILL.—The McKinley Syndicate is planning to extend their business in Bureau County, and will make gas for a number of towns and sell it for 75 cents per thousand feet, and is seeking franchises on this basis.

ST. LOUIS, MO.—The St. Louis Real Estate Exchange has a committee on Lighting, the purpose of which is to secure better illumination of the principal business streets of the city. The most novel feature of this movement is the proposal to erect ornamental posts supporting five incandescent lamps with diffusing globes, instead of the usual arc light. On the general subject the committee offers the following argument, as reported in the *Republic,* which may well receive the careful attention of city authorities and boards of trade generally:

"The cost of establishing this electrolier system of lighting in the business districts will be about six times as much as the present inadequate system, but it will give twenty times the amount of light.

"The volume of business done, because of the better lighting of the city, will be much greater, and will in itself pay for the additional expense. Aside from this it will increase the value of property. Then, too, it will save the city much in lessening accidents.

"If the streets are well lighted there will be less opportunity for crime in our city, the hold-up men will have to go out of business, and the citizens and visitors of St. Louis can go abroad in the night with the same feeling of safety that they have in daylight. It will make St. Louis a more active city.

"The time is propitious for making this splendid improvement, and it will be worth hundreds of thousands of dollars to our city if it will take the lead in providing this beautiful system of lighting in advance of other cities.

"While the cost of lighting the proposed districts will be nearly $150,000 greater annually than the present miserable system, in the matter of police protection alone, a saving will be made of not less than $100,000 per annum."

TROY, N. Y.—A bill has been presented in the State legislature authorizing the city of Troy to establish a system of electric lighting and power for streets and public buildings and for residential and commercial purposes. Five million dollars is to be the limit of cost.

UTICA, N. Y.—The Utica Gas and Electric Company has applied to the Gas and Electricity Commission for authority to increase its capital stock from $2,000,000 to $3,500,000. The Commission has promised a public hearing on the Utica application and it will doubtless be held soon after the Syracuse inquiry is concluded, if not during one of the recesses of the Syracuse session.

On the subject of ornamental lamp posts, Sylvester Baxter has the following to say in an article on "Art in the Street," in the March *Century:*

"Street furnishings like lamps posts, in their numerous repetitions, perform an important decorative function. We know that in decorative design the repetition of ornament is an æsthetic principle, producing its impression by the reiteration of a pleasing figure. But long-continued uniformity produces monotony; fatigue follows visual restfulness. Therefore, even when manufacturers produce good designs,

DESIGN FOR LAMP POST PROPOSED BY THE ST. LOUIS REAL ESTATE EXCHANGE.

it is undesirable that these should be alike everywhere, in town after town, for the eye would tire of seeing the same thing in all places. Hence each municipality would do better to obtain something distinctive. Indeed, the same thing should not be repeated all over one city; the standard pattern ought to vary with different districts, and perhaps with different streets. Locally individual significance might well be imparted to these things by embodying in the ornament of such furnishings some device, like a municipal seal, or arms, that in design would symbolize a distinguishing character of the place, as in site, trade or staple industry."

THE GREAT WHITE WAY.—BROADWAY AT HERALD SQUARE.

The Illuminating Engineer

Vol. I. MAY, 1906 No. 3

Practical Problems in Illuminating Engineering

By Arthur A. Ernst.

II.

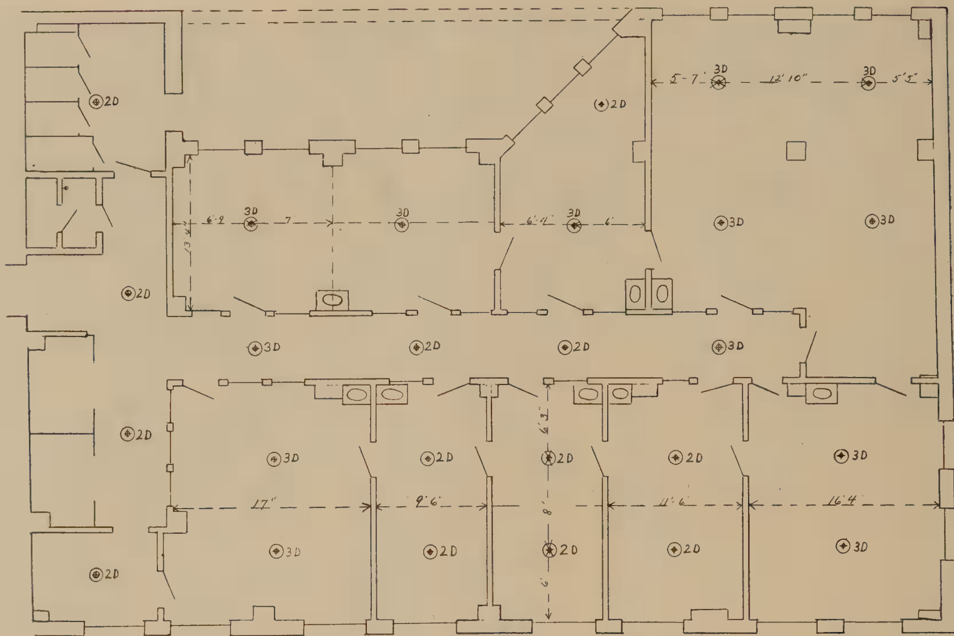
We will now consider the second floor of the building. The plan shows a number of rooms of various sizes and shapes, which are to be used as private offices. The elevator hall, toilet rooms, and vestibule are the same as in the first floor plan and need not be further discussed.

As shown, a corridor through the center of the building furnishes entrances to the several rooms. As a whole the problem affords a typical example of general office lighting, the conditions being the same as those of the regulation office building with the single exception that the uses of the different offices are fixed, instead of being subject to the various demands of different lines of business and different ideas of changing tenants.

The illumination in each room may be considered under two heads, namely; special, and general; special lighting being required for the desks, tables, book-cases, etc., and general illumination for the room regardless of the location of the furniture. This division of the problem is in accordance with the statement made in our previous discussion, that the only satisfactory method of lighting an office is to give each individual special illumination by which to work, and a general illumination for the room as a whole.

The special illumination will necessarily be afforded by means of lamps with shade reflectors attached to the desks, tables, or other objects where the special illumination is required; and as before stated, the only provisions to be made for this are plug receptacles placed in some sightly and convenient manner about the rooms. The electrical engineer in this case has suggested a method of accomplishing this in a manner that fulfills both conditions admirably. The method is as follows: A wooden molding is run around the room about three feet from the floor at the right height to serve as a chair rail; at requisite points in this rail flush receptacles are placed for making the necessary connections with flexible cord. This arrangement has the advantage over receptacles placed in the base-board of being easier to get at, less cord being required, and the cord being more out of the way.

As these offices are to be private, or semi-private and will therefore be

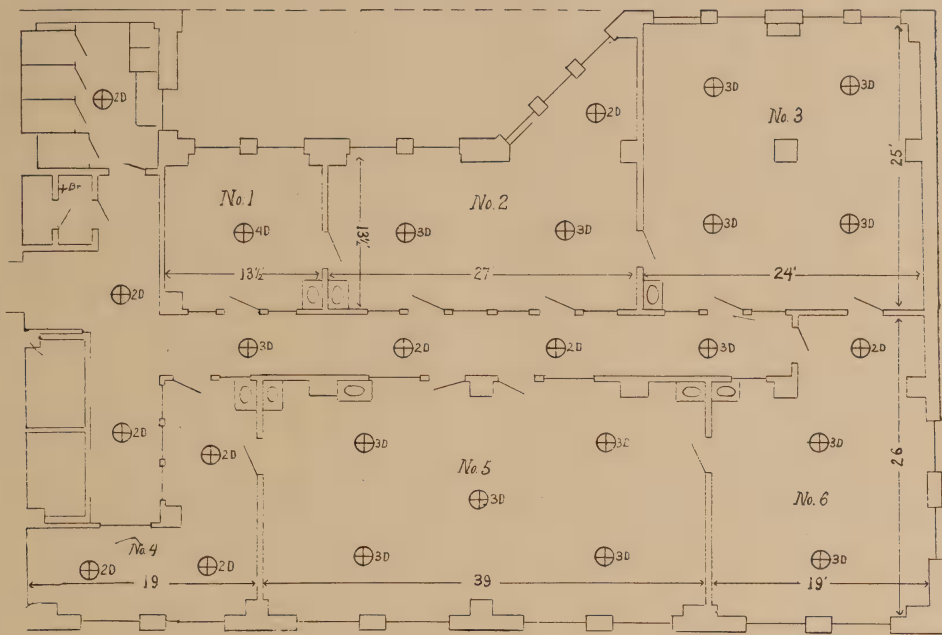


SECOND FLOOR PLAN.

visited more or less by outside people, it will be desirable to provide somewhat greater general illumination than that in the rooms which are for the use of accountants only.

We will first consider the corridor: The ceiling of this is divided into three panels by beams, as shown, and the simplest principles of symmetry would suggest the placing of lamps symmetrically in these panels. As the floor is fairly light in color, a half-foot candle illumination will be a sufficient minimum intensity. The ceilings on this floor are 12 feet high. By placing a 3-D (75 C.P.) unit in each of the two end panels and 2 feet from the ceiling, we obtain an illumination of .6 foot-candle underneath. In the central panel 2-D (50 C.P.) units at the same height may be used. It is desirable to keep the ends of the hallway slightly lighter than the center, as in looking the length of it the whole of it will appear light if the distance is light; while if the lightest portion is in the center, the ends will appear dark by comparison, and give a general impression of gloominess. It is also worth remarking here that in all passageways the floor is the surface to be considered. In walking, the eye involuntarily follows the path to be taken, very much as the head-light of a locomotive follows the track. If the path is well lighted there is a feeling, even though it may be an unconscious one, of safety and comfort; while a dark floor, no matter how light the side walls or ceiling may be, produces the contrary effect; that is, of hesitancy and caution.

In deciding the height at which the units should be placed the question of optical comfort is not less important than the question of efficiency and distribution. With the electric light, which unlike gas, may be placed in actual contact with the ceiling if desired, there is often a tendency to place the lamps as high as possible, depending upon some form of reflector to throw the light down; the argument being that it is better for the eyes to keep the light-sources as far above the line of vision as possible so



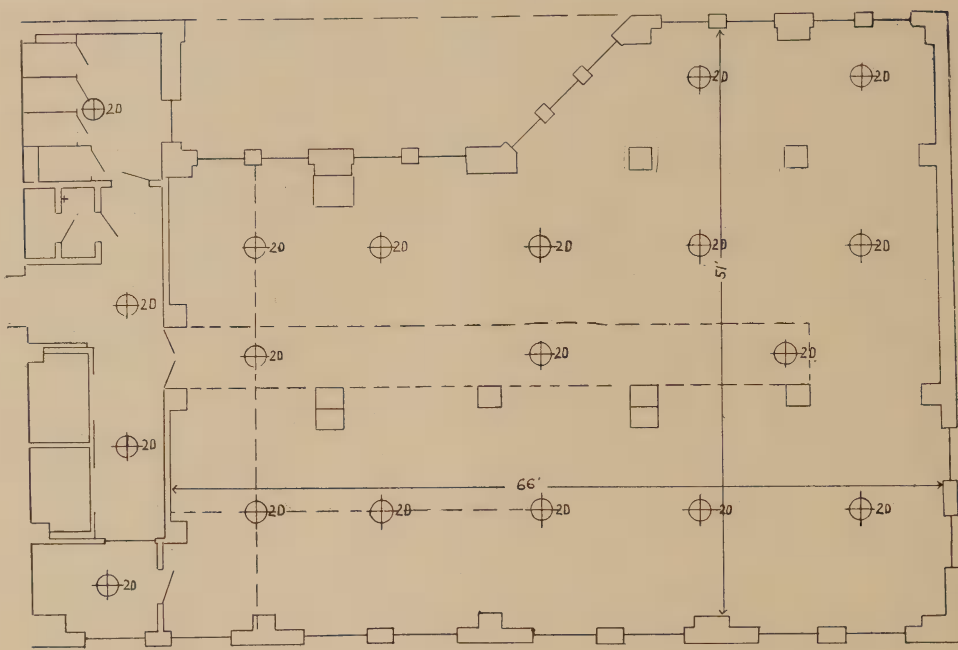
THIRD FLOOR PLAN.

as to prevent the eye from seeing the lights when looking in the ordinary direction. While the argument is highly plausable, both experience and a study of the normal conditions under which the eye works show that it is not well founded. The eye is not fitted by nature for viewing objects at an elevation, and ordinarily the field of vision takes in a very small angle above the horizontal; while in all close eye work the field is invariably below the horizontal. The eye is provided with a natural shade formed by the projection of the forehead and the lashes, which prevent rays from the higher angles from entering the eye. Furthermore, the eye in doing work is accustomed to light having only a small angle above the horizontal, coming in through windows which are commonly curtained from the top. A strong light from a high elevation therefore falls upon a portion of the retina unaccustomed to receive it, and consequently produces fatigue. While bright illumination from above is perfectly admissable in situations where people are moving about, or where they only stay for a comparatively short time, it is to be avoided in rooms for continuous use.

Efficiency and optical comfort therefore agree in dropping the lamp from the ceiling rather than placing it close against it. A drop of 4 feet will leave the lamp practically 2 feet above the line of vision, which is a fair average.

Third Floor.

Ceiling height, 12 feet, same as second floor. Elevator hall and toilet rooms the same. Office No. 1, single unit in the center. Office No. 2, three units. Office No. 3, four units. Corridor, same as on the second floor. Office No. 4, three units. Office No. 5 is noted on the plan as a work room. Four units might be used, but this would leave the minimum illumination at the center of the room; in this case it will be best to place a unit at this point, since a somewhat higher illumination is desired, and the center of the room should be a maximum rather



FIFTH FLOOR PLAN.

than a minimum. This differs from office No. 3, in which there is a column in the center of the room and consequently that point may be treated similarly to the space immediately around the side walls; that is, may receive a minimum of illumination. Office No. 6 might be treated in two different ways; either by four small units symmetrically placed, or two larger ones; the former would be the better arrangement if the room were to be used as a work room, but since for office purposes the desks will receive their special lighting, two units will be sufficient.

Fourth Floor.

The general arrangement and conditions here are similar to those of the second and third floors, and the arrangement as shown on the diagram will meet the conditions in a similar manner.

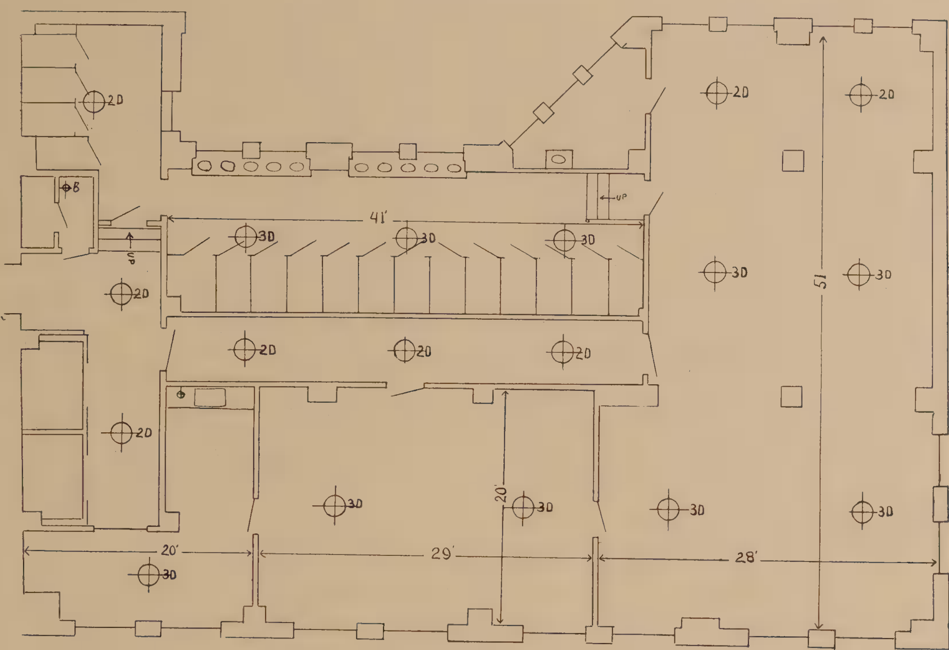
Fifth Floor.

The ceiling height of this floor is fourteen feet, and the entire room is to be used as the auditing room. The corridor is a head-high partition, so that the floor is practically a single room. Desks, files, etc., will be arranged as may be best suited to the needs of the business from time to time, no permanent arrangement being possible. The same general conditions therefore prevail as on the first floor. The distribution of units as shown will produce the required general illumination, while plug receptacles in the floor at convenient points will afford the necessary means of connection for the desk lights. The lamps will preferably be dropped four feet from the ceiling.

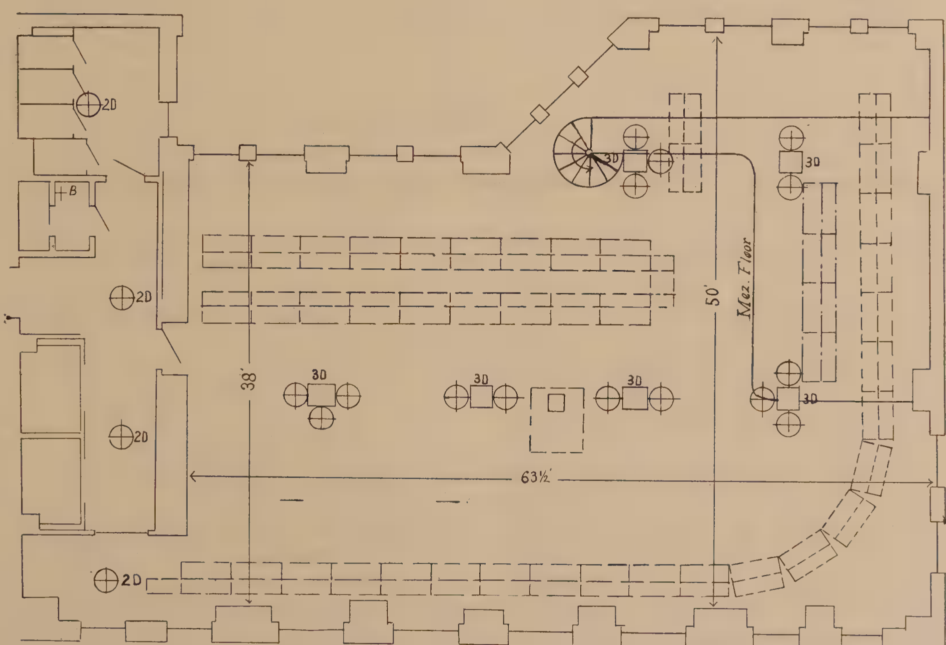
Sixth Floor.

This floor is of special interest, not alone as a lighting problem, but as showing the completeness of the building and the evident desire of the company to look after the general comfort and welfare of its employes.

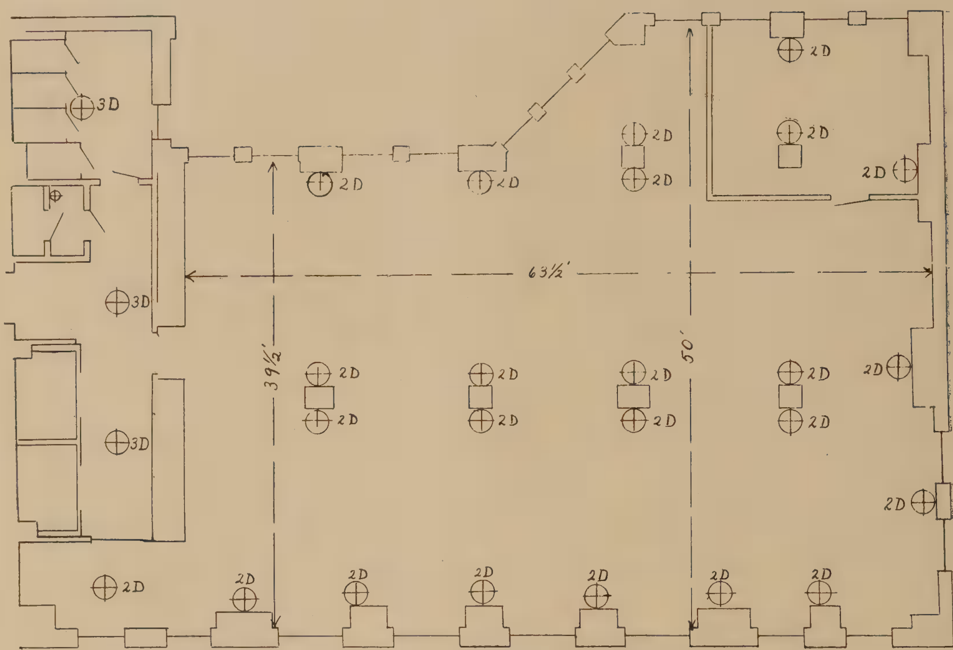
The elevator hall and corridor will



SIXTH FLOOR PLAN.



SEVENTH FLOOR PLAN.



EIGHTH AND NINTH FLOOR PLANS.

receive the same treatment as the other floors. The plan does not disclose the location of the most important feature of a ladies' toilet room, namely, a mirror, which is really a serious oversight; but such being the case the illuminating engineer is absolved from the responsibility of providing the proper light for it. In the triangular room to be used as a hospital a single unit in the center and a side bracket over the wash bowl will give sufficient illumination. Two rooms for which no specific purpose is marked may be given a general illumination in the manner shown. In the retiring room a moderate general illumination should be provided. In the dining room the disposition of the tables should determine the location of the lights, but these were not given on the architect's plans; lacking this, a general illumination may be provided by two units placed as shown. As the arrangement of tables will undoubtedly be permanent, it would be better had their location been known so that lights could have been placed uniformly over them. Thus, supposing that three tables were placed across the room as shown by the dotted line; then each table could have been properly illuminated with two units over it and dropped to within four feet of the table. In the kitchen a unit placed in front of the door will give a general illumination in both parts of the room and light the passageway from the dining room to the kitchen. A bracket over the sink should then be provided, and drop light in the position shown, which will give a good illumination on the cooking range.

Seventh Floor.

This is to be the toll operator room. The arrangement of the switch-boards is indicated by the dotted lines. A very mild general illumination is required here, and if possible, all light-sources should be kept out of the range of vision of the operator, as the switch-boards will of course be provided with special illumination. These conditions may be readily met

in this case by placing the light units on brackets attached to the posts as shown. By placing these sufficiently low, in this case seven feet from the floor, they will be hidden from the switch-board by the operators on one side of the room, and on the other side the operators sit with the lights to their backs, so that in no case will an operator see the lights when at work. The desks and special operating tables required may then be placed beside the posts and receive the greater intensity of illumination which they require. This makes a very simple and an ideal arrangement of lighting for the special purposes to which this room is to be put.

Eighth Floor.

As indicated on the plan, this is to be used as the terminal room, with a small room partitioned off as the battery room. The conditions required here are special. The terminals of a telephone system are arranged in successive horizontal rows something like the book shelves in a library, and are arranged on two sides of a dividing partition. The conditions of illumination are therefore somewhat similar to those in a library. A general illumination is required to see the numbers on the terminals, but for making the connections special illumination must be provided in the shape of a hand lamp attached to a flexible cord. A side light from units placed fairly low will meet the general conditions as nearly as possible. The terminals will be arranged in this case in two sections, as shown by the dotted lines. Side brackets placed between the windows on the side walls and on the columns will meet the requirements as specified. Plug receptacles for the hand lamps will be provided at suitable intervals on the racks supporting the terminals; the brackets should hold the lamps at such an angle as to throw the maximum light into the rows of terminals. In the battery room two units may be used as shown.

Ninth Floor.

This will be used for general purposes and for an extension of the terminals if required. The arrangement of lights on side brackets will therefore meet the requirements.

Tenth Floor.

As this floor is to be used for storage and similar purposes, a moderate amount of light will be sufficient.

Summary of Specifications.

Number of floor	1	2	3	4	5	6	7	8	9
Number of units	13	26	25	24	19	18	23	27	27
Total spherical c. p.	880	1,520	1,320	1,180	840	980	1,360	1,140	1,140
Total watts	2,300	4,000	4,000	3,680	2,400	3,050	4,200	3,500	3,500
Average S. C. P. per sq. ft. of floor	.22	.43	.37	.33	.23	.27	.36	.30	.30
Average watts per sq. ft. of floor	.51	1.66	1.66	1.02	.68	.85	1.16	.97	.97
Average S. C. P. per cu. ft. of space	.014	.035	.035	.027	.017	.023	.028	.026	.026
Average watts per cu. ft. of space	.036	.093	.093	.081	.049	.071	.088	.082	.082

BROADWAY AT MADISON SQUARE.—THE BEGINNING OF THE GREAT WHITE WAY.

The Great White Way

By Valentine Cook, Jr.

The portion of Broadway lying between 23rd and 46th streets is the best known and most frequented stretch of thoroughfare on the Western Continent. As might be expected from this fact, there is probably a greater amount of artificial light used, and a greater variety of methods of producing and displaying it, within these twenty-three blocks than in any equal length of street in the world.

There are portions of the downtown financial district that have a greater number of people pass through them during business hours; but every hour of the day is a business hour in the Great White Way. One familiar with its various phases may judge what hour it is of the twenty-four by the appearance of the street, but the judgment is based on the character of the passers-by rather than upon their number.

Within the distance mentioned there is located one of the largest department stores in the world, and another which is a good second, and more than a score of smaller shops dealing in every variety of merchandise imaginable. There are also the printing establishments of two of the leading dailies, one of which is international in its scope. Seventeen hotels offer their hospitality to the stranger within their gates; seventeen theaters cater to his amusement; and half a dozen high-class restaurants and cafés, and numberless eating places of high and low degree, are ready to see that he does not famish.

Starting at 23rd street, we face Madison Square, with its Garden at the opposite corner, in the tower of which Cooper Hewitt did his first work on the mercury vapor lamp. It is at 23rd street that Fifth avenue

crosses Broadway at a rather sharp angle; and on the triangle formed by the intersection of 22nd street, the Flatiron Building, probably the best-known building in America, is situated. Diagonally across 23rd street stands the Fifth Avenue Hotel, and in the next block above, the Hoffman House, both landmarks and intimately associated with the history of the two great political parties. The illumination on Broadway and Fifth avenue at this point is by means of enclosed arc lamps, two being supported on ornamental posts placed along the curb.

At 25th street, which is the upper boundary of Madison Square, the additional illumination afforded by the various signs and other devices used by the shops fairly begin. In the angle between Fifth avenue and Broadway, opposite the Flatiron Building, there is still one of the older and lower buildings, which furnishes a splendid opportunity for the use of an illuminating sign. As shown in the illustration, the sign used here at the present time is simply a bill-board extending the entire width of the building and illuminated by a row of incandescent lamps in a trough reflector placed forward of the board. This is one of the largest signs of the kind in the city, and the location is one of the most valuable.

Walking one up Broadway from 25th street, we pass the old Delmonico's Fifth Avenue Restaurant now Martin's, at 26th street, and the Hotel Victoria a block further on. At the next block on the right a changing sign advises us that we can have our photographs taken by night as well as by day, and two flaming arc lamps hung in front are evidently intended to emphasize the statement.

In the old days before Dr. Parkhurst "got busy," they used to have a "Red Light District," which subsequent reform administrations have succeeded in practically eliminating. The section we are now describing is frequently known as the "White Light District"; but if flaming arcs continue to increase, it will have to be re-named the "Yellow Light District." In the effort to literally outshine all competitors the intensity and number of lights had been multiplied, until it seemed that nothing further remained to be done to add to the general brilliancy; but when the flaming arc put in an appearance all other lights and devices shrunk into comparative obscurity.

At 27th street we have the general effect shown in the illustration, with the exception that the sidewalks are through with the usual crowd, and the

LOOKING UP BROADWAY FROM 27TH STREET.

trolley cars passing in endless procession. In taking the photographs, which required several minutes, moving objects obliterated themselves, leaving the delivery wagon as apparently the sole occupant of the street.

The Gilsey House, at the corner of 29th street, is an interesting relic of what was, not so many years ago, one of the grand hostelries of the city. It

was here that President Cleveland and his bride stopped on their wedding journey. The towering Breslin on the opposite corner is a fair example of the greater magnificence of the Greater New York.

At 30th street we may pause to take a view of the part of the street already traversed. The Hofbrau Restaurant sign is a good example of an electric sign formed with letters made of opalescent glass pressed into relief, and lighted by incandescent lamps placed within. While it does not have the sparkle of a sign formed by bare lamps, like the monogram sign above, for example, it is nevertheless an attractive sign both by day and by night. The letters in the other signs that show shaded are formed of red lamps. The large spats of light in front of Weber's Music Hall, and the others showing the same brilliancy in the illustration, are flaming arcs; and even though their yellow rays are not as powerful photographically as the light of the ordinary arc, their enormously greater brilliancy is still apparent in the result.

LOOKING DOWN BROADWAY FROM 30TH STREET.

Again continuing our journey we reach the point where Sixth avenue crosses Broadway at an oblique angle, forming two triangular spaces, which, for some peculiar reason, are known

BROADWAY AT 36TH STREET.

LOOKING UP BROADWAY FROM 38TH STREET.

in New York as "Squares." The one on the north side of 34th street contains the New York *Herald* Building, which may be recognized by the two illuminated dials, one showing the time, and the other the direction of the wind. At the corner of 34th street and Broadway is a small five story building, surrounded on the sides and overshadowed by the great Macy store. This building is capped with one of the most conspicuous signs in the city. The word "Hippodrome" and the pointing hand are in red letters, and the balance using clear lamps. The size of the sign can be judged by comparing it with the building underneath.

The small sign two blocks further, which shows only a streak of light, is the Marlborough Hotel sign; and although nearer than the signs that show on the opposite side of the street, it is practically illegible at this distance, showing evidently the effect of the use of too high candle-power lamps.

At 38th street we have the uptown office of the New York *World* on our left and the Casino Theater on the right. The *World* office has a large globe made of stained glass hung on the outside, containing two flaming arc lamps. The globe contains a considerable amount of glass of bluish color, which absorbs so much of the light that even the two lamps together produce only a moderate illumination. The office within furnishes an example of the illumination produced by the Moore vacuum light. The Casino Theater is gorgeous with signs and flaming arcs, being the first theater in the city to use this new lamp as an advertising attraction in itself, although the flaming arcs were used in the New York *World* device four years ago.

BROADWAY AT 40TH STREET.

At 41st street we get a nearer view of the tower-like building of the New York *Times,* sometimes called the "Andiron Building." The array of signs before us here is simply bewildering. Perhaps the most impressive of these is the one reminding us that it is time for a high ball, and incidentally giving us the exact time of the night.

Crossing 42nd street we reach another of the triangle "Squares," known as Long Acre Square, or by its new title of Times Square. With

BROADWAY AT 42ND STREET.

the continuous movement of business uptown, this section is now the center of the theater district, and has besides some of the newest and finest of the city's hotels.

In variety, size and ingenuity of electric signs the Great White Way is unsurpassed. Every trick and device that ingenuity can suggest and money produce seems to have found a place within these comparatively few blocks. In some of the larger signs striking color effects are produced; as for example in the Levy sign depicting a female figure, and in the Anheuser-Busch sign. Movements of various kinds are also one of the devices for attracting attention, the most conspicuous one being the Wilson High Ball sign, which changes every minute, thus giving the exact time. At the corner of 36th street, the windows on the second floor are utilized for advertising purposes, the front window having a screen on which stereopticon views are thrown, while the side window is sometimes occupied with changing pictures, and at other times with an actual "living picture" electrically illuminated. Perhaps the most novel and interesting of all the moving signs is the tall man with wide expanse of shirt front, which serves as a sign board, the letters placed upon it being illuminated from behind with electric light, the current for which is supplied from a battery carried in a suit case by a small colored boy at his side. The perambulation of this pair during the busy hours of the evening may be considered the limit of moving signs.

Looking backward from 45th street, we have the Hotel Astor at our right, and the sharp angle of the *Times* Building immediately in front.

The Great White Way may be said to end at 46th street, on the corner of which is located a large café. Although there are some large and prominent electric signs above here, the character of the street changes, being occupied largely by the automobile trade.

We have passed in this short walk

BROADWAY AT 45TH STREET.

probably every modern light and lighting device known—the enclosed arc, the incandescent electric lamp in every conceivable form of globe and shade, the flaming arc, Welsbach and incandescent gas burners of all descriptions, Nernst lamps, and the Moore vacuum tube lamp.

Having pointed the way and described its attractions briefly, we will now leave those who have followed us in our stroll to make a more detailed study of the illuminating prablems shown—or perchance to take the timely advice of the sign at 42nd street.

The Illumination of the Federal Building, Indianapolis, Ind.

By J. E. Woodwell

The United States Court House and Postoffice in Indianapolis, Indiana, designed by Messrs. Rankin & Kellogg, architects, and recently completed, is one of the most perfect applications of pure classical architecture to the requirements of a modern public office building in the country. Ancient architecture, unfortunately, affords few precedents which the illuminating engineer can safely follow, and the equipment of such a building with a modern system of wiring and fixtures is fraught with the dangers of architectural discord and violation of æsthetic principles. The study of the fixture equipment and detailed methods of illumination of the Indianapolis building was begun, as is too frequently the case, at a time when the wiring system was under contract and the position of the outlets fixed. What has been accomplished, therefore, has been subject to the limitation of securing a satisfactory illuminating result with conditions already established by the architects and with the fewest possible actual changes in the wiring system.

The general plan pursued in the selection and design of the fixture equipment was first of all to determine the general type of fixture required for each outlet with especial reference to the following points: location and use of fixture (public or working space, etc.); height and position of lamps; nature of design, whether simple or ornate; and character of switch control required. Each fixture outlet was thus scheduled and the equipment divided into two classes. The first class included all practical lighting fixtures

of simple form used in offices and work rooms, and for these complete designs and working drawings were prepared by the Government. The second class included all ornate and elaborate fixtures which from the nature of their surroundings and importance of location must harmonize with the elaborate interior architectural decoration and finish. To secure the talent of the specialists in the employ of the fixture manufacturers competitive designs were solicited, based upon a brief specification of the general type of fixture established for each important location, together with an estimate of the cost.

To illustrate the character of the information furnished the fixture bidders, one case is cited below, taken as an excerpt from the fixture schedule furnished the bidders.

"11—0 gas, 8 electric pendants, main corridor, height of ceiling 22′ 0″, fixture number 101, of a type to be supported by chain with pendant husk body designed to receive a spray of frosted lamps surrounding a center pendant glass ball of size to contain one 32 c.p. lamp, roughed inside, having cut star in bottom, and finished in old gold and black, $100 each."

The resultant fixture is shown in Fig. 1, the height at which this fixture and other corridor fixtures were hung from the floor being governed by the general requirement that fixtures of the ceiling type located in lobbies and corridors must be hung at such heights with reference to the design of the fixture as would accord with the ceiling heights of the corridors, etc., and interior finish, and with a view to securing effective and efficient illumination of the various spaces.

The main corridor on the first floor is elaborately treated and imposing in design, with marble side panels, projecting pilasters and mosaic groined arch ceiling. Flanked on the front side of the building by the Money Order, Registry, Postmaster and Assistant Postmaster's offices, and on the inner or court side by the Postoffice work room with its screen of lock

FIG. 1.

boxes, the main corridor extends the entire length of the building, over 340 feet. A satisfactory illumination is secured in this corridor by the use of the fixture shown in Fig. 1, seventeen of which hang in a line, a good downward and side illumination being obtained by the lower globe, while the cluster or spray of frosted lamps serves to light the elaborate mosaic ceiling. The height, about 12 feet, at which this fixture is hung above the floor was determined by experiment, so that without the use of reflectors, which would detract rather than add to the appearance in this design, the proper relative intensities of illumina-

tion on the floor and ceiling were secured.

Fixtures of the same general type but somewhat larger and with the bottom ball depending from the husk by a chain two or three feet long were placed in the main vestibules. In this case the upper cluster serves to illuminate and bring out the massive and

FIG. 2.

ROTUNDA.

decorative barreled arch ceiling built from blocks of carved Indiana limestone. The lower globes were dropped further to lessen the shadows on the colonade on either side. In each of the two elevator halls three fixtures of the design shown in Fig. 2 were used and hung lower than the main corridor fixtures to provide satisfactory illumination for the elevator entrance.

Efficient and effective results in the important office rooms on the first floor were secured by the use of pendant fixtures of the type shown in Fig. 3, which are actually equipped with 7-inch pagoda ball globes instead of the sandblasted globes shown in the photograph. The ring finial of the pendant fixtures illustrated serves to actuate a finial switch concealed in the body of the fixture and designed to control each light separately. Practically all pendant fixtures of three lights and over installed in the government buildings are equipped with finial switches of this type, in some cases in addition to the customary wall switch control. The use of such a switch adds but little to the cost of a fixture, renders unnecessary the use

of key sockets, and makes possible the exercise of a better working economy, in the use of light. A desk lamp connected to the proper socket on such a fixture, for instance, may be placed in service by turning the finial switch, while the other lights on the fixture remain extinguished.

In the two court rooms, located on the second floor at the east and west ends of the building, special fixture treatment was necessitated by the location of bracket fixture outlets on the face of sixteen pilasters eleven feet above the floor. The problem was best solved by the selection of the six light bracket fixtures shown in Fig. 4, the square back of bracket arm being designed to fit a space left blank in the fluted pilasters. Emergency gas lighting was provided by the ornamental gas flame tip surmounting the fixture.

The court rooms are richly ornamented and decorated in colors which give low factors of reflection. A small

MAIN CORRIDOR.

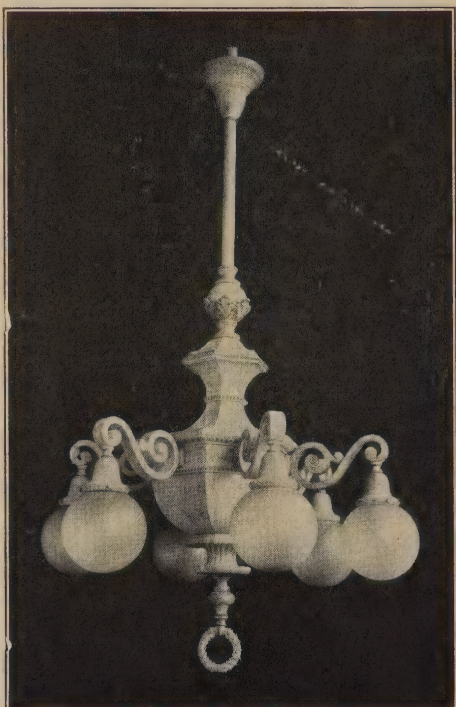


FIG. 3.

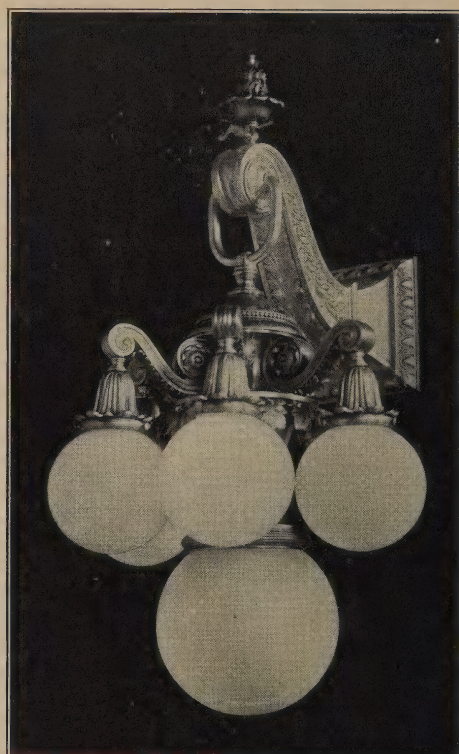


FIG. 4.

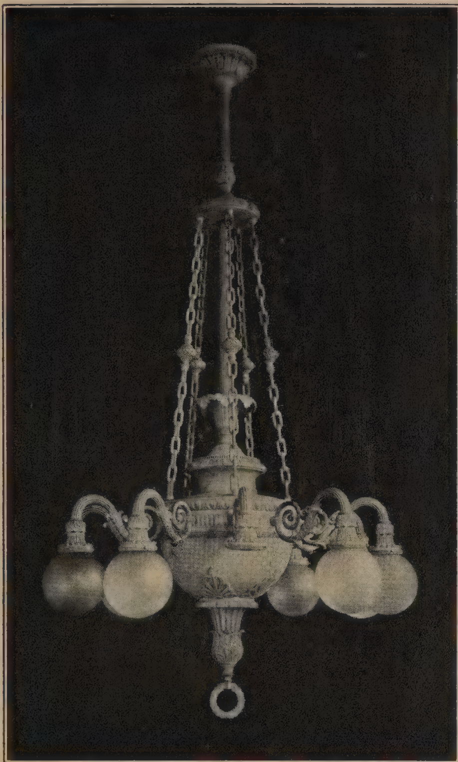


FIG. 5.

FIG. 6.

number of low candle power frosted lamps are used under the skylight for decorative effects, but the illumination of the room is practically wholly dependent upon the bracket fixtures. The result is successful from the architectural standpoint, and as artificial light is rarely required in the court rooms, efficiency is not the prime consideration; nevertheless the ratio which obtains of one 16 candle power lamp to 700 cubic feet of space cannot be considered excessive when the color scheme is considered.

ONE OF THE MAIN VESTIBULES.

Midway between the court rooms on the second floor is located the Judges' Library with the Judges' Chamber on either side. An elaborate fireplace forms the central feature in this room, which is richly decorated in blue and gold. The fixtures, Figs. 5 and 6, were arranged with the pendant in the center and a ceiling light fixture at either side, these latter being kept high to permit the arrangement of book-cases below, while the former was hung low to give a good reading light on a large center table beneath. At either side of the fireplace and on the

opposite wall were placed bracket fixtures of the design represented by Fig. 7, which together with the pendant fixtures give a good distribution of light in all parts of the room.

The main corridors on the second, third and fourth floors are fixtured

FIG. 7.

with simple 12-inch ground glass ball globes, each containing four 16-candle power lamps and fitted with ornamental holders and canopies. At the intersection of the main corridor on the second floor with the elevator corridors are large public lobbies forming entrance halls for the two court rooms. The size of the halls, 28 x 36 feet, and the provision of one ceiling fixture outlet, made necessary a special fixture design for these locations, consisting practically of an inverted pyramid of ball globes with a capacity of sixteen 16-candle power lamps supported by a suitable cast bronze ceiling plate of large dimensions. This treatment made it possible to keep the globes high, notwithstanding the fact that the ceiling height was only 13 feet 9 inches.

In the above description only the most elaborate fixtures have been mentioned, but the designs of lesser importance were studied with equal care, and included such details as the adaptation of gas fixtures for emergency use to such types as would harmonize with the treatment of the electric fixtures.

The fixtures used in the plainer office rooms and working spaces of the postoffice, etc., are of the character shown in Fig. 8, and were designed by the Government with special reference to securing the maximum economy in the use of electric current, and effective illumination, and to this end were especially adapted for the use of the several types of Holophane pagoda reflectors with which the fixtures are equipped generally throughout the building.

Considering the building as a whole the fixture equipment represented originally a factor of one 16-candle power lamp to 1,000 cubic feet of contents, and lamps of lower candle power than 16 have been substituted in many instances since the installation of the fixtures.

The exterior of the building is greatly enhanced in appearance by the elaborate lamp posts designed by the architects of the building to accord with the architectural treatment of the approaches and stone balustrades. The imposing and dignified appearance of the exterior fixtures in the daytime is

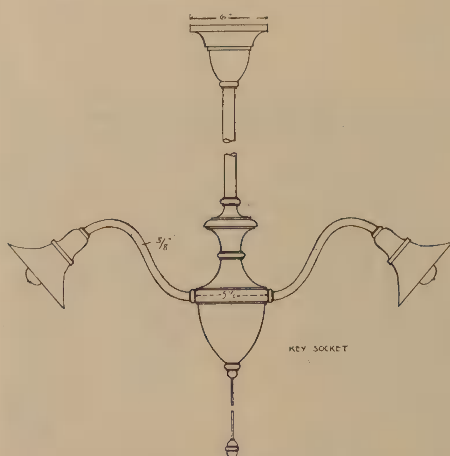
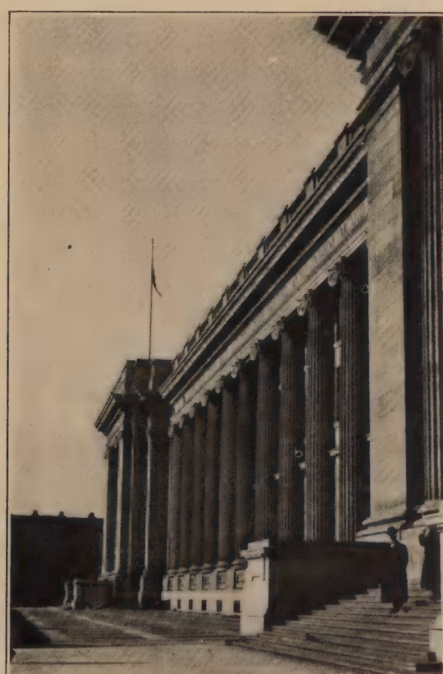


FIG. 8.

second only to the brilliant setting given by them when lighted at night. A view of the lamp posts fronting the main façade of the building is shown on the opposite page.

U. S. COURT ROOM.



THE ILLUMINATING ENGINEER

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SAN FRANCISCO: PAST AND FUTURE

The catastrophe by earthquake and fire, which wrought a greater havoc on the city of San Francisco than has ever before been visited upon any American city, is now a matter of history. It can hardly be spoken of as a "horror," for that term implies a calamity due to human negligence or malice; and the San Francisco disaster was clearly the result of a power which man, with all his science and learning, is as powerless to control as he is the rising and setting of the sun.

Loss of innocent life is irreparable; loss of material wealth can be restored by the process which created it, human labor. Calamities are the true tests of the moral stature of people; and it is one of the compensations for the lamentable loss of life that the display of heroism was abundant, and the performance of duty on every hand reached the heroic point, while the instantaneous and abundant outpouring of sympathy, expressed in both words and money, and not only from Americans but from the whole civilized world, was a convincing and cheering proof that modern civilization has made long strides toward the actual universal brotherhood of man.

With a knowledge that no blame lies on any human agency for what has befallen, attention may now be directed toward the future upbuilding of what will be the greater and fairer San Francisco.

Every one who has threaded the narrow and crooked streets of our larger cities, and observed the discrepancies in architecture between the earlier buildings and modern structures, must have had visions of what a city might be if laid out in accordance with modern facilities and ideas. Unfortunately it is only such superhuman razing of cities as occurred in San Francisco that affords an opportunity for the carrying out of such ideals. From the disaster, therefore, permanent beneficial results will accrue.

In the construction of the newer and better San Francisco the illuminating engineer should find an opportunity for exerting his talents toward increasing the excellence of the general results. In both street and interior illumination there will be opportunities for a greater uniformity and more artistic and efficient results than could be hoped for in any established city. Those who will be responsible for the rearrangement and construction should avail themselves of every art and science which can contribute to the excellence of the total result, and the Science and Art of Illumination is not the least among these.

THE DEATH OF PROF. CURIE

On April 19th, the day after the San Francisco catastrophe, a man was run down by a wagon and fatally injured in the streets of Paris. Some say that this accident, which in kind happens every day without more notice than a brief item in the daily press, occasioned a greater loss to the world than the San Francisco catastrophe. The man killed was Prof. Curie, who, jointly with his wife, discovered the element Radium.

The statement as to the magnitude of this misfortune, though apparently but the exaggeration of excited ad-

miration, is conceivably within the limits of strict truth. Hundreds of lives were snuffed out in San Francisco; by what basis of valuation then can this one life lost in the streets of Paris be accounted equal to the manifold greater numerical loss? Only on the basis of the difference in value of individuals to humanity in general. The work that Prof. Curie has done will live after him; it was not destroyed by his death. The loss to the world can therefore only be estimated by a consideration of what he might have brought forth had he been spared the usual alloted term of years. It is, of course, impossible to say what this might have been; but judging from the work which he did during his lifetime, it could very well happen that the results of his labor, had he been spared, would have been of value, both in money and in life, transcending the San Francisco loss. A discovery once made is never lost; a means of saving life by preventing or curing disease has uncounted possibilities, while the wealth resulting from improved methods of supplying human needs may be almost immeasurable.

This judgment of the loss represented in Prof. Curie's death, however, is wholly one of conjecture. There is a possibility that he might not have hit upon any additional scientific knowledge of transcendent value, though this possibility in the present case is exceedingly small.

The discoveries of Prof. and Mrs. Curie were of particular value to those interested in the subject of illumination. Of all the form of energy with which science deals, light is the one produced with the most extravagant waste in transformation; and even the discoveries which have been considered revolutionary in methods of light production have failed to reduce this inefficiency except to a relatively small extent. The work of the Curies was a breach in the walls which had hitherto held the knowledge of these mysterious forces in inviolable secrecy. The field has not yet been sufficiently penetrated by other explorers to determine what practical results may accrue, but it seems possible that the way has been indicated by which further research will in time lead to most important discoveries in the transformation of other forms of energy into that which we know as light. Fortunately for humanity, Mrs. Curie, who shared at least equally in the honors with her husband, still remains to carry on the work; and with the results already obtained, and the co-operation of numerous other workers in the field that has been thus opened for exploration, the full measure of results must in time be secured, though it is impossible to estimate to what extent they have been retarded by this untimely taking off.

Scientific geniuses are few and far between, and that they should be cut down in the midst of their usefulness is one of the inscrutable acts of Providence.

In their devotion to each other and to their common great purpose, the lives of Prof. and Mrs. Curie afford an example to mankind that is comparable in value to their scientific discoveries. On this subject the New York *World* makes the following observations:

> The fatality ended also a rare life companionship. The Browning union was not in a higher sense a marriage of true minds than the copartnership of the Curies in kindred interests and ambitions.
>
> They had literally consecrated themselves to science. They spent every penny of their slender means for pitchblende, tons upon tons of which were required to produce a single grain of radium, the philosopher's stone of their quest. Their garments were of the coarsest, Mme. Curie sharing every privation to advance her husband's researches. She herself pounded in a mortar all the pitchblende needed to yield the solitary particle of radium exhibited at the Paris Exposition. It was said of her that though she marred the beauty of her hands she did not waste a gramme of the precious mineral.
>
> Fame when it came could not lure the Curies from their simple life. The Nobel and Osiris prizes, amounting to $24,000, were to them not a means for luxury and display but for more pitchblende. Munificent offers from the great laboratories of the world, some of the most attractive from the United States, were declined for

a Sorbonne professorship for M. Curie, yielding $2,400 a year, and for Mme. Curie a $1,200 place in a Paris laboratory.

Curie was only forty-seven at the time of his death. He was forty-one when he sent to the Exposition the wonderful new element which was to upset the scientific theories of a century. There, as the story goes, a diamond merchant from India, finding that the substance discolored his exhibits, thrust it angrily aside into an obscure corner, from which only the accident of a visitor's curiosity brought it to the world's notice.

Had Curie more to do or was his life-work done? Was he on the track of yet greater discoveries in radio-activity or had he already served the divine purpose? The crunch of a cart-wheel leaves the question one of the world's mysteries.

Mme. Curie, whose co-operation with her late husband in scientific work was of editorial note in *The World* of yesterday, has been appointed to the chair of science held by M. Curie in the University of Paris. A more prompt and graceful public recognition of womanly, wifely and scholarly attainments was never recorded.

ILLUMINATING ENGINEERING AS A MEANS OF INCREASING CENTRAL STATION BUSINESS

Attention is called in other portions of this issue to schemes that are being used with some degree of temporary success, in this country and in England, by which both the user and the producer of electric current are defrauded. From these cases the following general proposition may be deducted: it is to the best commercial interests of central stations and gas companies to do all in their power toward assisting their patrons to secure the best illuminating results possible for the money expended.

This had not always been the case in the past, and there are probably still those who would shy at any improvement in illuminating practice which would reduce the cost of lighting to the consumer. The recognition which illuminating engineering is receiving tends directly towards making such practice an untenable one; while competition between different forms of luminants and different methods of producing light from the same luminant, also tend towards the same end.

One of the most valuable assets of any commercial enterprise is that wholly immaterial and sentimental commodity known as "good will"; and whatever tends to increase the value of this asset is of just as real commercial value as additions to manufacturing plant or real estate. Even where the possession of an apparent monopoly would seem to afford an opportunity of ignoring this fact, events have already shown that in the end the matter is more than evened up by the advent sooner or later, of a competition that is often disastrous in its effects. A glance over the "Miscellaneous News" will illustrate this point by the numerous cases given in which public disapproval has taken the form of more or less successful agitation for municipal ownership or control.

To come down to specific examples: a case which illustrates the point we wish to make was related by Dr. A. H. Elliott, of the Consolidated Gas Company, New York City, in his remarks at a former meeting of the Illuminating Engineering Society. The case he mentioned was as follows:

The company knew that there were still in use in the poorer districts of the East Side a great number of the old, wasteful, flat flame burners, which were retained on account of the inability of the tenants to bear the expense of buying new Welsbach burners. The company happened to have on hand a quantity of such burners that had been previously used. These were refinished at slight expense, and canvassers were sent about to place them at a trifling cost among the users. Wherever one of these burners was put in it of course reduced the consumption of gas for lighting by at least one-half. Having gained the customer's confidence in one matter, it was easy to gain it in another. The solicitors showed how the gas saved in lighting could be advantageously used for cooking. As a net result of the campaign a great deal more gas

was used by the customers than before the change in burners was made.

The same general scheme is capable of extensive application in the case of central stations. The vast majority of the patrons of central stations are those who consume current only for the application of light, and the general attitude of the consumer is usually to consider the lighting company as more or less of a natural enemy, whose aim is to despoil him as far as circumstances will permit. The only personal contact between consumer and producer is when the former pays his bill, which is usually, on general principles, considered excessive. Closer personal contact occurs only when dissatisfaction arises to the point where the consumer makes a formal complaint.

But why wait for a kick before making the acquaintance of the consumer? Why not send a courteous and intelligent representative, who, besides having the requisite tact of a salesman, has also some practical and available knowledge of illuminating engineering, to call upon the consumer, make his acquaintance, and ascertain if his illumination and the bills therefor are satisfactory? If they are not, let him suggest plans by which the lighting can be improved without increasing the cost; or better still, to improve it and reduce the cost at the same time, which can be done in nine cases out of ten. Even where the customer expresses himself as satisfied, ways could generally be found for giving him still better service. In either of these cases a general feeling of actual good would be established which would pave the way for the presentation of the advantages of using electric current for other purposes, such as power, and heat. Having gained the confidence of the customers by giving them a practical example of the company's interest in their welfare, any further suggestions would meet with favor in place of the usual attitude of distrust and prejudice. The total result would therefore be the use of a greater amount of current, which is the commercial end sought.

This policy would, of course, necessitate an understanding between the central station and its solicitors that the ultimate good will of the present or prospective consumer was to be considered of greater consequence than an immediate contract which would later lead to dissatisfaction and perhaps total cancellation, and that the solicitor who can give practical assistance to his customers is more valuable to employers than the one who can "set up an elegant line of talk."

THE ILLUMINATION OF THE SUBWAY STATIONS

We reprinted in our last issue an article on this subject which appeared in the *Electrical Review* on the 26th of last August, and a letter from Major E. L. Zalinski, which appeared in a subsequent issue of the *Electrical Review,* in which he took issue with some of the statements made by the writer. Our object in reprinting this was, as stated, to present some further discussion of the matter treated in the articles mentioned, believing that there were several points on which further illustration would be of interest to illuminating engineers.

The discussion of the subject diverted into too rather independent directions, one dealing specifically with the best method of illuminating the stations, and the other with the relative merits of different kinds of reflectors, with particular reference to those made of prism glass and those of glass having a white enameled surface. The latter question is one of fact rather than of opinion, and we have therefore had special investigations made along this line, a report of which will be found in another column. The question of the proper standard by which to judge of the illumination of the Subway stations is to some extent a question of opinion, and the relative values of opinions can only be judged by the arguments set forth in their substantiation.

In our article in the *Electrical Review* the position was taken that the proper basis for determining the sufficiency of illumination is the surface of the platforms; while Major Zalinski's contention, which was evidently the idea of the engineers who laid out the lighting, was that the standard of illumination should be that produced in a plane about five feet from the floor, or the position in which a paper would ordinarily be held to read while standing. We still contend that the Subway stations were not primarily intended as reading rooms, but that they are mere passageways intended to be occupied only so long as may be necessary to pass through them, or at most to await the arrival of a train, and hence the object of the illumination is to make ingress and egress as easy and expeditious as possible. In substantiation of this view we can do no better than to refer to the statement of Mr. Ernst on page 136 of this issue with reference to the lighting of hallways. No one who has been in them will deny the fact that, on entering, there is a sense of having to feel one's way, as it were, on account of the dim illumination on the platforms.

A reference to the curve given will show that the average intensity of illumination is less than .4 of a foot-candle, as determined from a photometric test of the lamps and globes in use. With the accumulation of dust which is usually present, it is altogether probable that this is reduced to .3, or even less. A .3 foot-candle illumination on a gray surface is entirely inadequate to allow one to walk with a sense of freedom.

The fundamental mistake in laying out the lighting of the stations was in using an insufficient number of lamps, or in other words, providing too small a total candle-power. Since the original article was written this mistake has been recognized and corrected in a number of stations by the awkward expedient of stringing additional wires and installing bare 16 candle-power lamps. It was shown that an average illumination of 1 foot-candle could be produced without these extra lamps by the substitution of a 40 candle-power lamp in the place of the present 32's, and of the most efficient form of prismatic glass reflector in place of the present ground glass globes and other inefficient devices. Why this simple change should not have been made instead of the more expensive and unsightly expedient of stringing up more lamps, is a matter which the engineers in charge can best explain.

Whatever may be said for or against the merits of the devices used, there is one fact which is absolutely indisputable—that the present illumination of the stations is ridiculously inadequate and inexcusable. Engineers who have in charge similar work will do well to profit by the lessons to be learned from this unfortunate experiment.

A CENTURY'S PROGRESS IN ILLUMINATION

It seems almost incredible that the entire development of illumination from its most primitive forms has taken place within less than a century. On the front cover we give a reprint from a celebrated drawing, showing what may be considered in some ways the prototype of the present central station. While the watchman who went his rounds with a lantern was primarily a policeman, the fact that it was necessary for him to carry a lantern in order to find his way about the streets and alleys of London, the chief city of the world, is in itself a sufficient index of the character of the street lighting of that time. The watchmen, going forth from their watch-house, and carrying their sickly oil lanterns, are in a way a counterpart of the enormous engines and dynamos sending out their electric current to illuminate the streets at the present time: and there are those still living who can remember seeing a watchman as shown in the illustration!

Research and Investigation

Conducted by The Illuminating Engineer

PLAIN VS. ENAMELED PRISMATIC GLASS REFLECTORS

An article on the diffusing reflector, by Maj. E. L. Zalinski, the conclusion of which will be found in another part of this issue, brings up the question as to the relative merits of clear prism glass reflectors, and the same form of reflector with a white enamel on the outside. Believing that the data and arguments given by Major Zalinski left a number of points undecided, we have had a number of experiments made, and tests upon the reflectors carried out by the Electical Testing Laboratories.

Summing up the various contentions, the points in dispute may be summarized as follows:

1st. Does the coating or enameling of the prism on a prismatic reflector destroy the optical reflection?

By optical reflection is meant that which is commonly known as "total reflection," which takes place when a ray of light, after passing through a dense medium, strikes a rare medium within the critical angle.

2nd. Which form of reflector is the most efficient, regardless of the cause of reflection?

3rd. What are the relative merits of the two forms for general illuminating purposes?

The first question was sufficiently answered in the affirmative by the tests shown in Major Zalinski's discussion in which a reflector enameled on the inside shows practically the same efficiency as one enameled on the outside; but to decide this point beyond a peradventure, the following experiment was made:

Reflectors were made as nearly as possible of the same contour and size. No. 1 was of plain glass both sides. No. 2, with the usual 90° prisms on the outside, plain on the inside, and enameled on the out or prism side. No. 3 was of the same form, but enameled on the inside.

The test shows that the plain glass reflector is the most efficient of the three. This is exactly what would be expected from the theory.

In the enameled prism reflector there is more or less reflection from one face of the prism to the other and consequently more absorption by the enamel.

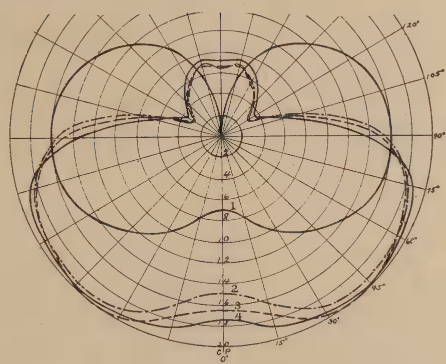


FIG. 1.

Curve No. 1. Bare lamp.
Curve No. 2. Prism reflector enameled on outside.
Curve No. 3. Prism reflector enameled on inside.
Curve No. 4. Plain clear glass reflector enameled on outside.

This experiment proves conclusively that the prisms have absolutely no action in producing reflection in case they are enameled, and that if enameled glass is to be used, the plainer the surface the better. While this experiment was unnecessary in view of the well-known principles of optics which are involved, there are a great many laymen who are, figuratively speaking, "from Missouri," and are much better satisfied after being shown with their own eyes that an asserted fact is true.

The answer to the second question would appear from the cases cited by Major Zalinski to be in favor of the enameled reflectors, but there were at least two respects in which the experiments which he carried out would lead to inaccurate results:—(1) Apparently only reflectors of a certain make and shape were tested. The results therefore could not prove the general proposition, but only that the particular make of the prismatic reflector tested was less efficient than an enameled reflector. This might very well happen, as the reflecting power depends in large degree, upon workmanship and design. (2) The tests reported by Major Zalinski were made by the use of three lamps with a "wireless cluster." Why this awkward and unscientific combination was used in these experiments, the writer does not explain. Such an arrangement of necessity brings the lamps close to

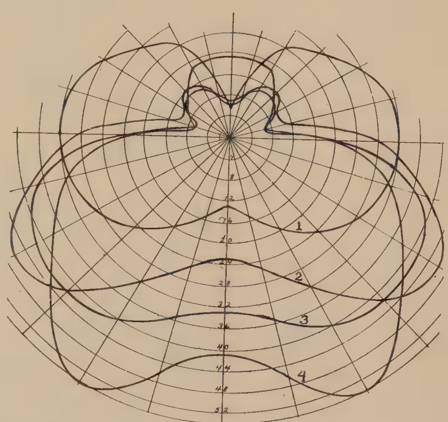


FIG. 2.

Curve No. 1. Bare 32 c. p. lamp.
Curve No. 2. Clear prismatic reflector.
Curve No. 3. Enameled prismatic reflector.
Curve No. 4. Clear prismatic reflector.

the inner surface of the glass, and this throws out to a considerable extent the effect of total reflection; that is, it has practically the effect of a light-source enormously increased in surface, and the Major calls attention in his discussion to the fact that not all of the rays can be totally reflected unless they emanate from a point source. With a single lamp placed centrally in the reflector,—and there is no necessity for any other arrangement,—the deviation from the theory is comparatively small, and hence a

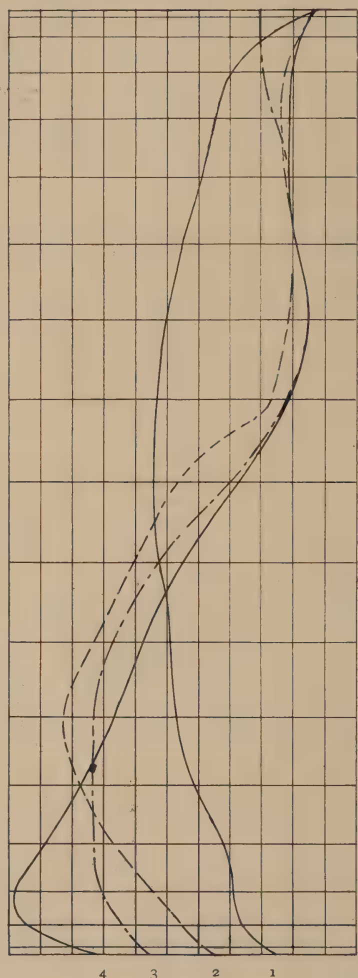


FIG. 3.—ROUSSEAU CURVES.

No. 1. Bare 32 c. p. lamp.
No. 2. Prismatic reflector.
No. 3. Prismatic reflector, enameled.
No. 4. Prismatic reflector.

larger amount of the light is reflected.

In experiment No. 2 three reflectors were made, two of them of similar size and shape, one of which was enameled on the outer surface, the other having its contour modified so as to give a different distribution.

The three were then tested with a regular 32 candle-power lamp placed in the proper position; the results are shown in curve, Fig. 2.

The facts brought out by this test are as follows:

1st. The total reflecting power of prismatic glass when properly designed and used is larger than that of white enameled glass.

2nd. A prismatic reflector properly shaped, and with the lamp in a definite position, is capable of giving a wider distribution than enameled, or any other form of diffusing reflector.

3d. By changing the contour of prismatic reflectors it is possible to vary the distribution as desired within very wide limits, while with white reflectors only one distribution can be obtained.

This latter fact is highly important, as it enables the natural distribution of a light-source to be so modified as to produce a given illumination upon a predetermined surface to a greater extent than can be obtained with any other form of translucent reflector. The maximum amount of light therefore can be directed practically within any desired zone.

It is not necessary in view of the above facts to go into a detailed description of the numerous contentions in regard to enameled reflectors. The results given clearly establish all the facts claimed from a theoretical standpoint.

It is not to be understood, however, that they entirely discredit the enameled reflector as a form of diffusing reflector. From the point of artistic appearance they are undoubtedly much to be preferred to reflectors made of either opal glass or enameled metal, and their efficiency is such as to render them acceptable from an engineering standpoint. By dispensing with the useless prisms, and using a purely ornamental configuration for the surface, highly decorative effects may be produced, the enamel giving a peculiar satiny appearance, unlike any other form of reflecting surface.

A SCHEME FOR "WORKING" THE PUBLIC ON ILLUMINATION

An ingenious scheme, which depends upon the prevalence of faulty methods of lighting and public ignorance of the elementary principles of illuminating engineering is being worked with more or less success in various cities. The *modus operandi* of the scheme is as follows: The user of electric lamps is approached by an agent and told that his lighting bills can be cut in half by the simple expedient of replacing his present lamps and shades with a special lamp and "prism hood,"—as the apology for a prismatic reflector is called. The combination lamp and "hood" is presumably too valuable to be parted with, so the customer is permitted to lease the outfit on consideration of his paying the lessor half of the saving effected in his bills for current. A contract is offered which, on the face of it, is to the unwary a perfectly fair business proposition. The lessor agrees to equip the premises throughout with his combination lamp and hood, the same to remain in place for one year; and no other lamps or apparatus are to be installed without permission. In short, the lessor practically assumes entire control of the lighting installation, and receives in compensation half of the reduction made in the cost of the light.

There is one omission in the contract, however, which is decidedly important to the lessee, or customer; *there is absolutely no statement or guarantee as to the quality or amount of illumination that will be furnished by the alleged improved apparatus.* It does not therefore take much of a genius to guess how the scheme is worked. A 16 candle power lamp is replaced with a 4 candle power lamp, of slightly different shape from the ordinary commercial form, but labeled "XV," (candle power omitted!) and fitted with the smallest size of prismatic reflector. The reflectors thus far placed are of somewhat fanciful pattern, having the prisms spirally

arranged, and the agent makes many claims as to the advantages of the "gyrating rays" produced by this spiral arrangement. "Gyration" is a happy expression: the most accomplished patent medicine or electric belt fakir has never surpassed it. Naturally, the 4 candle power lamp reduces the current consumed by a very considerable amount; and, it is needless to remark, also reduces the total light produced to one-fourth the original amount. The customer therefore has his light reduced to one-fourth of what he has been having, and pays monthly a handsome sum for the privilege.

A few figures will show how it works out in practice. Let us suppose the following case:

A customer is running one hundred 16 candle power lamps five hours per day; 100 lamps, 56 watts each=5,600 watts; 5,600 watts five hours per day =28 K.W. hours per day; 28 K.W. hours at 10c.=$2.80 per day.

There is substituted for this one hundred 4 candle power lamps, 16 watts each=1,600 watts; 1,600 watts 5 hours per day=8 K.W. hours; 8 K.W. hours at 10c.=$0.80 per day; difference in cost of current $2.00 per day.

For rent of the outfit therefore the lessee pays $1.00 per day; or, counting twenty-five business days to the months, $25.00 per month for the privilege of having his light cut down one-fourth of what it was originally. At the end of the year he has paid $300, and if dissatisfied, can have his original installation put back again; in which case he has absolutely nothing to show for the money expended except the reduction in light and current.

The fact that the user can be persuaded that he is getting satisfactory illumination by the use of these comparatively inefficient "hoods" and four c. p. lamps is an evidence of the wastefulness of the usual form of globe or shade, and an indication of what can be done with the best devices and intelligent engineering. By this scheme the customer uses a four c. p. lamp and pays, including rental for the installation, an amount equal to the cost of running eight c. p. lamps.

To make sure of just what was being offered in this scheme we have had tests made by the Electrical Testing Laboratories of the lamp and reflector offered. The results are given below.

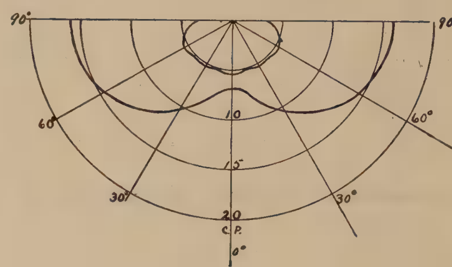


FIG. 1.

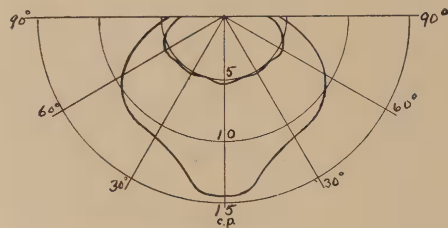


FIG. 3.

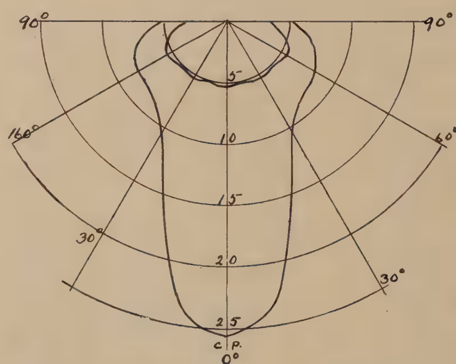


FIG. 2.

In Fig. 1, the inside curve is that of the four c. p. lamp and hood used in place of the 16 c. p. lamp; the outer curve is that of the 16 c. p. lamp bare. In Fig. 2, the inside curve is that of the 4 c. p. lamp and hood, while the outside curve is one obtained by the use of a high class prismatic reflector

with 8 c. p. lamp. In Fig. 3, the outside curve shows a different distribution obtained from an 8 c. p. lamp with a high class reflector. The inner curves in Figs. 2 and 3 show the light which the consumer gets by his rental scheme, while the outer curves show the light which he could obtain from the same expenditure after the slight first cost of the installation. The difference in the amounts of light may therefore be considered the tax which he pays for his own ignorance of the subject, or his neglect to employ the services of a competent illuminating engineer.

The customer could have gone into the market and purchased one hundred of the highest grade of prismatic reflectors of similar size for $35. In case he is getting free lamp renewals from the lighting company, which is now the general practice, this would have represented his entire cost for the improvement, and he would have had the reflectors for permanent use thereafter. In case he was buying his own lamps he would have had to purchase, on a liberal estimate, 300 lamps at 16c. each, costing $48.00. His total expenditure would have been $83.00, as against $300 on the leasing scheme, and his expense thereafter would have been but $48 per year instead of $300.

Stripped of high sounding words, the proposition is this: "I will show you how to reduce your lighting bills more than one-half; for showing you I am to get one-half of the saving." It is agreed. "Very well; use lamps taking a quarter as much current." It is identical, except in the nature of the expenditure, with the following proposition: "I will show you how to reduce your living expenses 50 per cent.; for showing you I get one-half of the saving." Good. I then get a smaller house than can be rented for a quarter what you are now paying, and furnish you a quarter as much food; for this service you pay me one-half the difference, or one-fourth of your present living expenses.

It is worth mentioning that the peculiar designs offered in the renting proposition are simply ingenious attempts to evade the patents by which the standard reflectors are protected; and it is particularly worth noting that these attempts have not been successful, as at least one of the forms has already been adjudged an infringement and its further sale enjoined, and suits are pending against the other forms offered.

That the great majority of illuminating installations could be improved, both as to quality and efficiency of results, is only too apparent to those familiar with the subject; but just as the sick are a prey to the numerous horde of charlatans who profit by their eagerness for health, so the numerous and generally recognized faults of lighting afford an attractive field for schemers seeking to profit by the unfortunate conditions that exist. The incandescent electric lamp itself is so easily juggled as to make it an attractive species of gold-brick. It would be an edifying piece of statistics to show how much good money has been obtained by the simple trick of displaying with the proper air of mystery an undervoltage lamp. The scheme of using a silvered stem which would reflect the filament and thus give the lamp the appearance of having two filaments, and therefore, according to the fakir, twice the light-giving power, is probably familiar to many of our readers. It was on some such hair-brained proposition that a large amount of capital was raised, and even extensive buildings put up for the manufacture of the improved lamps not many years ago.

Prof. Aggassiz epitomized the public reception of scientific discoveries as follows:

First: It is impossible;

Second: It is contrary to the Scriptures;

Third: Everybody knew it before.

Following a similar method of classification from the commercial point of view, the three epochs in the development of an invention might be characterized as follows:

First: It is scouted as only a scientific curiosity that can have no practical use;

Second: It is exploited by charlatans and fakirs who live upon the gullibility of the public;

Third: A general scramble of competitors to imitate the improvement or steal it outright.

Electricity in general has not yet entirely emerged from the second stage, as a large majority of the public are still quite unfamiliar with the subject. The various alleged electrical devices which are claimed to cure the numerous ills that flesh is heir to are abundantly in evidence and apparently largely patronized.

Illuminating Engineering, the newest of the special branches of applied science, is evidentally about to pass through this second period of its development. There has been a sudden and general awakening of the people to the fact that ordinary methods of lighting are wasteful and unsatisfactory, and any scheme by which this condition can be removed is accordingly attractive. The subject is undoubtedly the least understood of any question of equal importance at the present time. This is particularly true of illumination by electricity, since electricity itself is still to the average user a profound mystery; volts, amperes, watts, candle power, distribution, diffusion—all of these terms, which are common parlance to the illuminating engineer, are equivalent to so much Greek to the uninitiated. "A little knowledge is a dangerous thing," especially when it is used as a basis for the purchase of an important commodity; and it is the consumer who, having some slight knowledge of the subject, is most readily beguiled by the glib tongued promoter of pseudo-scientific schemes.

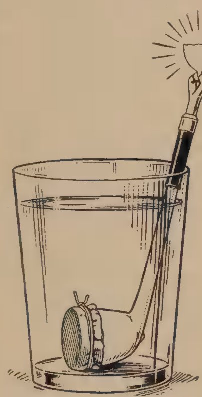
The prism glass reflector, which is a scientific improvement of unquestioned value in illumination, is one of the latest inventions to be exploited by those who live on the credulity of the public. A prism reflector is an exceedingly simple device to those familiar with the elementary principles of optics; but as the average user is unfamiliar with even these elementary laws, there is opportunity for much darkening of counsel as well as of illumination by words without knowledge. Thus, it is a comparatively simple matter to use the term *"illumination"* to imply that a prism reflector increases the *light* of a lamp. It is quite proper to state that a reflector increases the *illumination,* provided that the reader or hearer is given to understand what is meant by the term; but to make the statement without defining the term is a manifest attempt to deceive. To be sure, any other kind of reflector will increase illumination within a certain region, but the ordinary forms of reflector are too familiar to be thus juggled with. The prism reflector is new and unfamiliar, hence its virtue for this purpose.

As might be expected, the scheme does not continue to work indefinitely. The loss in illumination, though not so apparent at first, is sure to impress itself upon ordinary observation in the course of a little time, and it is therefore unusual to find an installation of this kind that has been in operation for any considerable length of time.

The recital of facts above set forth has a moral for both the Central Station manager, and the consumer of current: the former should employ one or more competent illuminating engineers, whose duties should be to see that customers get the best possible *illuminating* results for the current consumed; while the latter should investigate the credentials of those who pose as experts, and obtain the advice of engineers of established reputation before signing such important contracts.

Facts and Fancies

An advertisement which has been running in several well-known periodicals is deserving of notice on account of its originality and cleverness. It is in the interest of acetylene lighting, and tells "how to make cheap gas light for country homes."



Take a common clay pipe.

Put a simple "Acetylene" Gas-burner on its stem.

Bind the two in position with a tight-fitting piece of Rubber Hose.

Then fill the bowl of the pipe with fine-ground Calcium Carbide.

Next tie a rag over head of the bowl to keep in the Carbide.

Now put the pipe into a Glass of Water, as in picture.

There you have a complete Gas-plant for 25 cents.

Touch a match to the Burner—and you'll get a beautiful White Gas-light.

Of course, this is only an experiment, but it shows the wonderful *simplicity* of Acetylene lighting.

ACETYLENE AS A SUBSTITUTE FOR DAYLIGHT

Speaking of acetylene illumination, a new use for it, which seems to have some possibilities of reaching commercial proportions, has been discovered by the Agricultural Department of Cornell University. This use is for the purpose of forcing the growth of plants in greenhouses. The following notes on this subject are from a recent issue of the New York *Herald*:

Only a few years ago the possibility of using acetylene light in the production of greenhouse plants came under the attention of L. H. Bailey, director of the Cornell College of Agriculture, and Professor John Craig, head of the department of horticulture in that college. It was decided that experiments of sufficient extent and thoroughness to determine the scientific and commercial value of acetylene light should be carried through.

Electric light may also be used in place of acetylene, but it is much more expensive. It may seem peculiar that precisely the same results are accomplished by these two lights, but such is the case. With electric light, however, a very strong arc must be used and then enclosed in an opalescent bulb in order that the ultra violet rays may be taken out. One day's exposure to these rays would mean the ruining of all the plants the light struck, and the amount of electricity that must be used up so that enough white light may go through the opalescent bulb is so great as to render the use of electricity a commercial impossibility. Acetylene in comparison with it costs almost nothing. Hence while electricity in this connection is also very interesting to the scientist, it attracts little more than the idle curiosity of the greenhouse gardener.

One remarkable fact about the acetylene burner is that it has no harmful effect on any plant, though on some it produces little effect. In the Cornell greenhouses the delicate tomato vines grow within five or six inches of the flame of the burner, just as well as they do ten feet away. In some cases the application of acetylene light will produce "diminishing returns," as the economist puts it, that is, it does not pay for the good you get out of it.

"It costs just about so much on an average to run a greenhouse for thirty days. Suppose you can save ten days on a crop that it takes about thirty days to grow under natural conditions, that is, suppose you use acetylene at night to keep up the work of the sunlight. That means that in three months' time you will have been able to raise an extra crop. The big advantage of this from the practical standpoint you can very easily see if in getting this extra crop you do not add too much to the cost of production. If acetylene light is used the extra cost is rarely as large as the benefit derived from it."

A NEW ELECTRIC LAMP FOR PHOTOGRAPHIC USE

The use of artificial light for various photographic processes has become a matter of no small importance. It is a well-known fact that the rays which have the most powerful effect on the chemicals used are those of the blue and violet color, together with rays that produce no visual effect at all. The most powerful source of such rays of the present time is the high

voltage enclosed arc lamp. A clever arrangement of a lamp of this kind for photo-copying purposes is shown in the illustration, and is due to Mr. W. N. McBeth, of Philadelphia. It consists simply in an inverted form of enclosed arc lamp placed upon a tripod standard and fitted with a suitable reflector. The convenience and general neatness of the arrangement are readily apparent, the inner globe being as easily removed as a chimney from a kerosene lamp. In setting up the outfit a resistance and switch are furnished, so that where it is to be used for taking color values a lower voltage current can be thrown in so as to give a white light in place of the blue and violet due to high voltage.

HOW TO READ COMFORTABLY ON THE CARS

The feeling of discomfort that is usually felt on reading in a moving train is a matter of common experience, and the practice, if persisted in, is generally considered, probably rightly, to effect permanent injury to the eyes. A physician has suggested that this discomfort, with its attendant injurious effect, can be practically removed by the simple expedient of sitting backwards in the car. The explanation given is that the exterior objects are seen only after having been passed, and with a receding motion, and therefore the images do not, as it were, strike the retina with a blow. A rapidly approaching object instantly gives an impression of danger, keeping the eye unconsciously strained to protect itself. To those who have suffered annoyance in this way and who are accustomed to reading under these conditions the suggestion is well worth a trial.

PHOTOGRAPHING BLUE PRINTS

A foreign periodical has an article describing a method of successfully photographing a blue print. Summed up, the process consists simply in using a yellow-sensitive dry plate—the commercial orthochromatic or isochromatic plates serving sufficiently well, and a yellow color-screen over the lens. Blue and yellow being complimentary colors, the yellow color-screen will cut off the blue rays, while the orthochromatic plate will be sensitive to the yellow rays corresponding to the white lines on the print. The result will be as strong a negative as if the original were drawn with white lines upon a black ground. Since both the orthochromatic plates and color-screen can be readily obtained of any photo supply house, the method can be readily carried out without special preparation.

AN INGENIOUS METHOD OF LIGHTING CANDLES

Electricity has usually claimed for itself the sole means of lighting up any number of lamps simultaneously; but in this, as in other cases, there seems to be nothing new under the sun. The *Youth's Companion* has the following interesting description of a method of producing this effect when candles were the best light-sources available.

In these days of electric lights, with all their capabilities for brilliant illumination, it is amusing to read what the subjects of George II. considered a dazzling effect. A Frenchman, visiting in London at the time of the coronation of that monarch in 1727, writes enthusiastically in praise of the lighting of the city, as well as of a banquet display.

"Most of the streets," writes Monsieur Saussure, "are wonderfully well lighted. In front of each house hangs a lantern, or large globe of glass, inside of which is placed a lamp which burns all night. Large houses have two of these, suspended outside the doors by iron supports. Some even have four.

How one arc light would have dazzled the good people of that day!

"When the coronation procession entered Westminster hall," the writer continues, "the light of day was beginning to fade. Forty chandeliers, in shape like a crown, hung from the ceiling, each having 36 wax candles.

"On the king's appearance all suddenly lighted, and every one in the room was filled with astonishment at the wonderful and unexpected illumination. Little cords of cotton wool, imperceptible to the eye, saturated with sulphur of saltpeter, spirits of wine and other ingredients, had been prepared and arranged so as to carry the flame rapidly from one candle to another. The arrangement had been so skilfully prepared that scarcely a candle failed to take fire."

SEA-SICKNESS AND THE EYES

Many people have no doubt noticed, when traveling by sea, that the motion of the ship could be seen very distinctly, even when there were no hanging lamps, draperies, or fixed points, such as the horizon or clouds, within range of sight. Some may think that seeing the motion in this way is due to the imagination receiving the suggestions from the motion of the internal organs, and especially the stomach, for I am here supposing the body to be held perfectly rigid.

From observations which I have recently made it seems evident to me that the cause for seeing the motion is entirely different. In the first place, you can always see the motion a fraction of a second before you begin to feel it. In the second place, you cannot see a perfectly horizontal motion or a gentle vertical (heaving) motion. In the third place, watching a fixed point close to you, such as a pattern on a carpet, when the ship is pitching and rolling, is far more tiring to the eyesight than when the ship is motionless or running steadily. All this points to the appearance being due to a true relative motion of the eyes to the ship.

The eyes are suspended in their muscular settings, much in the same way as are ships' compasses in their binnacles. The eyes are, furthermore, perfectly balanced, so as to make their muscular displacements as little tiring as possible. In their normal position, the pull of gravity is exerted vertically through their centers, and the muscular mechanism is compensated for gravity.

Any angular change of position will displace the eyes just as it displaces the stomach, excepting that the eyes, being a great deal more sensitively suspended, will register the displacements more quickly. It it not, however, the motion of the eyes which strains the eyesight, but the act of resisting this motion.

If, with your eyes shut, you attempt to fix the mental representation of a point, which a moment previously you were watching with eyes wide open, you will find that, after one or two motions of the ship, the bodily feeling will precede any visual sensation which your imagination can conjure up. The imaginary point is no longer fixed, but follows the eyes as they let themselves go to the motions of the ship. No strain of the eyesight is caused by a muscular resistance, and the displacements, while felt, can no longer be seen.—*Pittsburg Letter to London Nature.*

The Illuminating Engineering Society

Papers Presented at the Meeting Held in New York April 13th

NOTES ON INTERIOR ILLUMINATION

By Douglass Burnett

The program of papers to be submitted to the Society and the papers that have been read show that a great deal of attention is being given to the different kinds of lights that are available, and the object of the writer is to point out the great importance of supplementing this work by more definite information or rules by which lights, and particularly electric lights, should be arranged for securing proper lighting effects. There is a great deal of information available as to the different kinds of electric, gas and other lights, as to the distribution of lighting in vertical and horizontal planes around them, and as to the performance of the different devices using these systems. For instance, we may know the characteristics of the different kinds of gas lamps, arc lamps, incandescent lamps, and high efficiency electric lamps, but when it comes to a question of laying down rules by which these different kinds of lights should be located for illuminating different spaces and the conditions under which one or the other of the kinds of the lights should be selected for certain circumstances, we are much more dependent upon the individual opinion, knowledge or experience of the particlar man who is arranging the lay out.

The illuminating engineer is a creation of the last few years. This man works in coöperation with or by direction of the architect, and has to determine what kind of light to use, what size lamp unit, and how to arrange these units in the different spaces and buildings which may be brought to him. But so far as the writer knows, there is no code or set of general rules by which he can operate, which have been based on the experience of others who deal with the same problems, nor does he know, except by personal experience, what is the current practice.

The American Institute of Electrical Engineers created a committee on standardization some time ago with markedly good results to electrical engineering. It seems very probable that if we could in the same way lay down standards we would have made a great step forward, especially if we could get that code or set of standards adopted or approved by the national bodies of architects.

As manager of one of our large electric light companies, the writer often sees instances where particular cases of illumination would be improved if there was such a code or set of rules which could be followed, in preference to leaving the matter open to the opinion of the particular electric light solicitor or company representative, or even, as is often the case, to the user of light himself.

There are certain questions of general policy which have developed within the last few years, as a result of which the central station service has been made more and more satisfactory to the users of electric light. For instance, experience has shown the desirability of furnishing free incandescent lamp renewals and the first equipment of lamps, and of inspecting the condition of lamps, all with the object of improving electric lighting service. The writer personally knows of a case in which the condition of incandescent lamps in use by the customers of a certain company was verv bad, the company declined to furnish any lamps without selling them; a more liberal policy has resulted in an improvement of the service of fully 100 per cent.

The same company found that there were many cases in its territory in which excellent results came from the use of 5-light incandescent clusters, and many people were found to be entirely satisfied with the results who had considered the cost of wiring as prohibitive. For instance, we have a dozen or more public market houses in different parts of the city, each occupying from one to three small city blocks, and each occupied by from 200 to 900 separate stalls owned or leased by individuals who formerly used gas lighting. One market building had about twenty-five electric light customers using pendant drop lights, and another building two or three arc light customers. We tried the regular arc and the low energy arc lamp and the pendant drop incandescent lamps, but could not establish the use of much service until we adopted the practice of loaning the 5-light clusters. These clusters generally pay for themselves in one or two months on the revenue obtained, and now there are a considerable percentage of the stalls wired up and using the current. The point of this is that this particular device best met the particular conditions, and the customers of the company were very quick to discover the fact.

These are questions of general policy which show the good results of giving careful attention to the different cases that come up, and if we could go one step further and lay down the proposed rules, we would accomplish still better results. It would be splendid to be in position to say that the national body, the Illuminating Engineering Society, has said that the opinion and experience of its members indicates that under such and such conditions of space to be lighted, use of this space, scheme of decoration and color of the walls, then such and such lighting units should be used, located in such and such a way, to secure the best results.

The question of lighting a certain railroad station came up some time ago, the railroad engineer stating that the lighting was carried out by means of chandeliers, which he proposed to displace by larger lamp units in less number attached directly to the ceiling. Dr. Nichols sent the writer a letter,[1] showing that it could not be definitely predicted which of the two methods of lighting was the better. The proposal to place lights on the ceiling without fixtures has been carried out with good results in office building practice, and there is one instance of a general office building occupied by a railroad company which has received very careful treatment, the lighting being laid out on a watt per square foot basis, the number of watts varying with the different uses of the different rooms.

[1] "The question of the illumination from incandescent lamps which you propose is of considerable interest. I do not think, however, that a general answer can be given as regards the relative effectiveness of the two methods. Very much depends upon the reflecting power of the walls and ceiling of a room. Some pigments have a high absorbing power, and in such cases the light received comes for the most part directly from the lamps themselves. In such a case it is desirable to arrange the lamps so that their mean distance from the regions to be illuminated shall be a minimum. One must of course avoid bringing the lamps themselves within the direct range of the eye to avoid the unpleasant dazzling effect. For other pigments the reflecting power is so large that the direct distance of the lamps themselves is not the chief factor in the illumination secured. In the latter case it is unquestionably better where the lamps are placed near the ceiling and particularly where they are placed in lines parallel to the side walls rather near the latter. We have a room set aside for such experiments upon illumination but have been prevented from carrying out extensive measurements as yet by press of other work. In order to make a test of the matter of value it would in my opinion be necessary to color both walls and ceiling with the surface to be used in the finishing of the room in question. Measurements made with the wall and ceiling colors other than those to be employed in a given case would scarcely apply. This whole question is one of great practical importance to those who are engaged in the lighting of interiors and a systematic investigation of it should unquestionably be made. The solution of the problem, however, involves the standardization as regards diffuse reflecting power of the numerous pigments and surfaces used in the decoration of walls and ceilings so that the work is one involving considerable expense and large expenditure of time. In the case which you cite of the passenger room of the railway station, for example, the average illumination is in a plane three feet from the floor might with certain treatment of the walls be much greater with the chandeliers at a height of 10 ft. than with the same number of lamps disposed in the ceiling, whereas with other pigments the latter arrangement might be found quite as good, and it would have the advantage of a better appearance and of securing a much more uniform lighting of the whole space."

Some of the questions which have arisen in the recent experience of the writer and some illustrations of his point of view are now given.

For show window lighting, is it not

best to recommend against the use of high power lights, such as arc lamps, Nernst lamps, or chandeliers? Is it not best to recommend against the use of cone reflectors set into a false ceiling, on account of the poor distribution of the light? Notwithstanding the display value of the lights, should not we recommend against the use of border lights in show windows, and is not the trough reflector the best one that we can adopt? To the writer the answer seems perfectly plain, though some of the central station companies do not seem to agree.

Is it good practice to light a department store with chandeliers having about twenty incandescent lamps each, in order to get a certain effect of display, or is it always better to use arc lamps? The writer has known of one large department store, the proprietor of which very much prefers the chandelier method. In department stores, is there not a certain minimum height of ceiling at which incandescent lamps should be used in preference to arc lamps, for the purpose of avoiding the glare and of shortening the fixture?

In the basement of a store where crockery and glassware are displayed, is it not important to have the lights arranged over the aisles instead of over the center of the tables, in order to bring the source of light over the customer's head and to do away with shades?

For store fronts, should we not recommend against arc lights in the doorways, and in favor of incandescent lights in the windows?

If a department store is lighted throughout with a type of lamp which does not give the true color values compared with daylight, and if the proprietor wishes a few arc lamps for matching colors, it is advisable to assent, and thereby interfere with the scheme of lighting?

For a millinery store where goods of delicate colors are shown, are not arc lamps preferable to incandescent lamps, on account of the color value of the arcs?

Is it ever advisable to use arc lamps at a silversmith's show room or a jewelry store? The writer knows of one individually equipped silversmith's shop with about a thirty-foot ceiling in which the white light of Nernst lamps is very much preferred by the proprietor. The writer's opinion has been that it would be better to stud the ceiling with incandescent lamps, or else use clusters in such a case in order to increase the number of points of light, and in order to get the yellowish light with which people are most accustomed at home.

For drug stores, is it not always advisable to use incandescent lamps for general lighting, on account of the average store being small, and so that the scheme of general lighting will fit in with the decorative lights around the soda fountain?

With concentric ceiling diffuser for arc lamps, what rule should be followed for spacing the lamps when 5-ampere, 120-volt direct current lamps are used, and what rule for 7½-ampere lamps?

Is it not always advisable to use an opalescent ball globe for arc lamps in interior work in order to remove the glare; but if porcelain shades are used, should not convex shades be selected in preference to concave, for the reason that the streaks of light formed by the concave globe will spoil the appearance of many goods displayed? For instance, it will make clothes and suitings appear as if they had been through a fire or had been water soaked.

For office lighting, should not every desk or reading light either be placed on the ceiling near the wall, or shaded in order to take away the direct glare?

Is it ever advisable to use a strong source of light such as an arc lamp or a Welsbach cluster, when the place is only large enough for a single one of such lamps, and in such a case is it not very much better to use small light units such as incandescent lamps?

Is it not best to use a studded ceiling in a ball room in order to increase the sparkle on the jewels worn by the

guests, and is not concealed or cove lighting to be specially avoided for this purpose?

In an art gallery, should not all the light be shaded and trough reflectors used for paintings to secure even illumination? And on the contrary, for art galleries with statuary, should not high power lights be used to intensify the lights and shadows?

For theater lighting, is it not important to place any lamps that are in view of the audience around or on the balconies against the face of the balconies towards the stage, and to carefully avoid the use of stalactites and low-hanging chandeliers, on account of the glare, and for the purpose of increasing the impression of the space being large?

These points just recited with reference to illumination have been put in the form of questions, so that if there is any doubt it may be cleared up, and some of them are given for the reason that there are certainly many people connected with lighting propositions whose attention has not been drawn to the proper treatment of them.

The writer is quite aware that some central station companies have made it a practice in special cases to have a lighting engineer in the employ of the company lay down the lighting plans, with the expectation that they will be adopted by the customer, but in such cases the location and arrangement of the lights and the type of the lights selected is largely a question of individual opinion, as there is nothing to show what standard practice throughout the country requires as represented by the decision of any particular set of experts. Such plans have been prepared in our own office, and our customers have very much appreciated the service we have performed, but we desire to have a check on the accuracy of our recommendations. These are special cases. Generally the customer says to the electric light man that he thinks he will wire for so and so many lights, or the electric light man recommends that he use such and such lights disposed in a certain way, but another electric light man in the same company may recommend very differently. We need to get an authoritative expression of opinion as to just what rules shall be laid down for guidance in such cases.

There are several papers that have been presented in connection with this matter in past years to engineering societies, but none of them begin to cover the field. There are several excellent papers on record in which measurements have been made in connection with systems of arc lighting for streets, and the writer has several, beginning with the paper of Mr. A. P. Trotter, read before the Institute of Civil Engineers in 1892, in which measurements were made and the lines of equal illumination were plotted. A few instances of such interior measurements of lighting have come to the writer's attention, but the cases are scarce indeed. The question of interior illumination should be subject to the same class of experimentation as has been given to street and road lighting.

Cohn once stated that at school or a working desk the minimum illumination should be 10-meter candles with the Hefner unit as the basis, and that good lighting was represented by 50-meter candles. Hutchinson in 1897 made some measurements on the illumination of the Congressional Library, showing that it varied from .25 to 1.87 candle feet. Fowler in 1902 made some measurements with a special luminometer, indicating that the average illumination was ½ candle foot for street lighting at a certain place, and 1½ candle feet for office lighting. Paterson in 1905 gave some measurements of street lighting by gas, showing that the illumination varied from .238 to .253 candle feet, and that the electric lighting varied from .610 to .620 candle feet. Ryan in 1905 changed the basis of rating illumination by giving the results in several classes of illuminated spaces as from ½ to 1¾ watts per square foot, but as the writer has said elsewhere in this paper, in order to consider any such

basis we must have in mind the efficiency of the light source in watts per candle.

Several recent papers by Messrs. Cravath and Lansingh on the arrangement of lights in the home furnish the nearest approach to anything that the author has in mind, though there was one English paper presented about a year ago that made some measurements of the actual amount of lighting in different rooms.

A list or schedule of the different classes of buildings to be lighted should be prepared, as for instance, office buildings, department stores, small retail stores, wholesale dry goods, notions, etc., factories and railroad stations, and the sub-heads should be given showing the different classes of rooms in these different buildings. For each class a statement should be made showing which type of lighting is not suitable and giving the reasons. They should also show what is in general practice considered the best arrangement of the remaining classes of lights. For instance, arc lights are hardly considered acceptable for furniture stores and carpet stores, and neither are they to be accepted for general office work; neither are incandescent lamps best suited to department store lighting.

And that brings up the question of just what is a suitable standard for the arrangement of arc lights in department stores. Generally a new department store of any considerable size is laid out with rows of columns at right angles, from 15 to 25 feet apart, and this architectural consideration requires that each arc lamp should be located in the center of a bay. There have been cases in the writer's experience in which the location of arc lamps as given by the architects had to be changed very considerably in order to secure the best results. We say that an arc lamp should be located 12 feet from the floor, with one lamp to every 225 square feet to 400 square feet of floor space, using the 500-watt multiple arc as the basis.

One question to be considered is, as to whether to make our rules on a basis of the number of candle-power or watts per square foot or per cubic foot, or whether to specify the foot candle as the unit of illumination. Already some very good results have been secured by laying out the illumination on the basis of from 1 to 2 watts per square foot. But this basis neglects the efficiency of the lamp unit, since 1 watt per square foot from the arc lamp would give a very different volume of light from the same figure as applied to an incandescent lamp; and we cannot neglect the distribution of the light by means of reflectors, since some recent papers on shades and reflectors (published in the *Electrical World*) show that the light of a 16-candle-power lamp in the useful direction may be increased three or four times.

An editorial in the same paper in discussing methods of street lighting said as follows: "We would like to see a careful comparison between the various systems of street lighting based, not on distribution and operating expenses alone, but on the watts per mean candle foot at the areas to be illuminated." It is needless to point out that in a comparison of the different electrical methods, this basis would give an absolute measure of the efficiency of the particular method under consideration.

SOME NOTES ON GAS ILLUMINATION

By R. M. Searle

It seems that the greater portion of our efforts now should be devoted to seeing that the present consumers of our products are taught to use their lights to better advantage. To do this each one of us must take every opportunity to show others how to get the highest efficiency out of their appliances, whether the case under observation is in your territory or others; often do we see the user of illuminants start out with clean appliances, and as they become clouded with dirt they

have to double the unit of light in use and then condemn the purveyor. If ordinary clear glass obstructs ten per cent. of light, and opal globes sixty to seventy per cent., imagine the loss to the consumer when chimneys or bulbs build up on their surfaces successive laminations of opolescence, resulting in various percentages of loss. It does seem strange that it is necessary, in this age, to prove that it pays to keep clean. This loss of light due to fouling of globes, is very much more serious where ground glass globes or opal globes are used, than with clear glass; as the fouling is so gradual and so near the color of the globes themselves, that it takes months before they are so foul as to be easily noticed. In the meantime additional units of light are brought into use and expense increased to the consumer. We also have the same loss with Holophane globes, if not kept clean.

Another source of benefit to all concerned is proper supervision of maintenance. Many cases have come to my notice where a consumer starts out with a home equipped throughout with incandescent gas lights; first, the light in the kitchen gets wrecked, then hall light is wrecked, then servants' room light is wrecked; just about this time a vendor arrives with a supply of aluminum tips, and the consumer replaces these lights with them, with the result that his cost of lighting is immediately doubled. Here is one of our greatest fields of opportunity to educate and convince the consumers of our being able to help them, if they will appeal to us.

This also illustrates the value of inspection of old consumers' premises and keeping in touch with them; their children, bear in mind, are our future customers.

Since my first attendance at one of the meetings of this Society, I have given a great deal of thought to various points that have come to my notice. One is the great necessity there is to get more wisdom in distribution of light in homes of people of moderate incomes. For instance, why not more often, where design permits, place hall lights where they serve to illuminate the hall and throw soft rays through parlor or living room door; why not place kitchen light so that major portion of lights are thrown on sink, table and range; why always in middle or only on side of kitchen? It is just as much our duty to make our service practical as it is to make it artistic.

Another phase of the subject is the selection of the proper color of light or globe for a given decoration. People are, and will continue to use the schemes of interior decoration most in vogue; when changes are contemplated we can do good work by advising together on just what type of light and globe should be used.

In older homes, and many new ones, imitation candles with small inefficient tips are found; it is seldom that all the tips on these chandeliers are brought into use, and when they are it is generally on "state" occasions, while the rest of the time the consumer is using gas as extravagantly as possible; it is our practice to substitute the best type of tip obtainable, arrange them so their edge is in line with the center of fixture this gives all the light, does not to any extent injure the effect, and if a "state" occasion obtains, we are thanked for the excellent service given that night. This is one of the conditions in lighting by gas that is well worth following up.

When we undertook the changing of candle tips to efficient burners we met some skeptics who thought the plan was to increase their bills instead of helping them. I designed a rubber socket, carrying a standard open-flame burner; our men in the consumer's presence first lighted the small tip and adjusted cock, then they blew the light out, slipped the socket over and lighted good tip, showing the consumer the difference between using the same amount of gas through an inefficient tip and through the best to be had. In the language of the "patent medicine man," this has convinced the most skeptical.

Another source of criticism is the

use of globes with bottom openings of small diameter; this causes draughts up through globe, that in turn set open-flame burners flickering badly, causing eye weariness and in many cases the substitution of oil lamps; globes and holders are cheap. It will pay us to do all we can to wipe out the use of the old type of globe; many thousands are still in use.

While I appreciate that incandescent gas lighting is largely on the increase, open flames will be used a long time after we are gone, and anything we can do now is bound to pay in the long run.

By encouraging the use of portable reading lamps we can economically serve our consumers almost regardless of the decoration of the room. If portable lamps in some cases are impossible, more side outlets should be put in. It is well from every standpoint to increase the number of side outlets on new work.

We frequently find that one or more persons in a household prefer different rooms to read in, and if side lights are in you can equip consumer with a suitable light to read by. Reading lights are the best long burning units of light in domestic use.

Before ending these remarks I want to urge of you to try to help our cause along by giving the consumer the benefit of our knowledge and that no one be allowed to "knock" any system of illumination, decoration or design, but lend his help in the true sense of the word.

DISCUSSION

Mr. V. R. Lansingh:—Mr. Burnett says "For show window lighting, is it not best to recommend against the use of high-power lights, such as arc lamps, Nernst lamps or chandeliers? Is it not best to recommend against the use of cone reflectors set into a false ceiling, on account of the poor distribution of the light? Notwithstanding the display value of the lights, should not we recommend against the use of border lights in show windows, and is not the trough reflector the best one that we can adopt? To the writer the answer seems perfectly plain, though some of the central station companies do not seem to agree." I do not agree entirely with the author, and shall take up some of the points on which we differ. In the first place, a customer generallly puts light in his window in order to display his goods, although this is not always the case. Sometimes lights are used purely to attract the passer-by, but generally speaking a man puts lights in his window in order to display the goods therein. In order to display goods well, it is necessary to hide light sources from the eye, and this absolutely precludes the use of border lights, unless they are thoroughly shaded. There are a number of cases in New York which I have in mind, where border lights are used with good effect, but the lights are shaded by means of oval, ground glass or aluminum reflectors, and the illumination is very good. Of course, these can have a strong illumination of goods, and a soft decorative light in the window. This has been tried in many cases, and in such case a soft light from the chandelier or some other system, with well-shaded globes, sucn as opal or ground glass, or something of that kind can be used with good effect and attract the passer-by, but you must not depend on this means for the illumination of the window. There must be other lights. Under such circumstances it is, therefore, in my opinion, undesirable to use arc lamps, Nernst lamps, or chandeliers for light, unless, of course, such lights are placed very high and provided with proper reflectors to throw the light down.

In regard to the use of trough reflectors as opposed to cone reflectors, it is my opinion that the trough reflector is not, generally speaking, as efficient as the cone reflector, for this reason that the latter catches the light from the incandescent lamps on all sides and throws it down. The trough reflector, on the other hand, catches the side light, but does not catch the under light and throw it down. The photometric curves of the cone reflector and the trough reflector show this very well. If, however, you want to light the back of a window as well as below, the trough reflector is the best. From tests published in the *Electrical World* some time ago, it appears that a trough reflector, with a certain number of lights, gave 60 candles on the horizontal, which would light the back of the window well, and gave about 120 downward. But for the man who is displaying his goods on the floor of the window, that would not be efficient.

Mr. Burnett asks: "For store front, should we not recommend against arc lights in the doorways, and in favor of incandescent lights in the windows?" I think that it is demonstrated from the remarks I have just made, that an arc light should never be used for lighting a window by placing it outside.

Another question is—"Is it ever advis-

able to use arc lamps at a silversmith's show room or a jewelry store?" One of the handsomest jewelry stores in the country is Leeson's, at Salt Lake City. They have adopted arc lights for lighting the store proper, and the effect on the jewels is very fine, especially on diamonds, the specialty of this firm, the color of which is brought out better by the arc light than even by daylight. A stone which has only a slight tinge of blue under daylight, and none under the incandescent lamp or the Nernst lamp, shines with a brilliant blue under the arc, due to the violet rays of the arc itself. For this reason they do not use an opal globe, which would modify the color of the light.

Another query is—"For office lighting, should not every desk or reading light either be placed on the ceiling near the wall, or shaded in order to take away the direct glare?" With respect to writing desks, there are a number of considerations to be taken into account. First, the light should be fairly strong, and in my experience I believe it should vary from 3 to 5 candle-feet, normal to the horizontal. Too much light, however, is more often used than too little. The chief engineer at Marshall Fields' establishment, in Chicago, told me one time that the amount of light used by the bookkeepers in their stalls in the building had been multiplied five times since he took charge, and that there were only one or two, and they were recent additions to the bookkeeping force, who were not wearing glasses, due partly to the excess of light, and partly to reflection from the glaze of the paper—and lamps are so placed that light falling on the glazed paper is reflected in large measure directly into the eye, which contracts the pupil and tires the retina, finally resulting in the use of spectacles or the calling for more light. To light a desk properly, the light should come from the left hand side in case a man is right-handed, and from the right hand side in case he is left-handed, so as to prevent shadows being thrown on the paper from the hand; and it should come from the side, or a little behind, and not from the front. The room should also be somewhat lighted, so that a person looking up will not have a sharp contrast between a brilliantly lighted desk and the darkness of the room.

Another query made by Mr. Burnett is as follows: "For theater lighting, is it not important to place any lamps that are in view of the audience around or on the balconies against the face of the balconies toward the stage and to carefully avoid the use of stalactites and low-hanging chandeliers on account of the glare and for the purpose of increasing the impression of the space being large?" I thoroughly agree with the writer in this suggestion. I do not know of anything more tiresome than to sit in the rear part of a theater having lights placed on the under side of the balcony. You have to look against the lights—the pupil of the eye contracts, the retina becomes strained, and you go home with a headache.

Speaking of arc lights, Mr. Burnett says: "For instance, arc lights are hardly considered acceptable for furniture stores and carpet stores, and neither are they to be accepted for general office work. Neither are incandescent lamps best suited to department store lighting." I will take up the last sentence first. Some of the best illuminated department stores in the country are not lighted with arc lights. The store of Marshall Field, in Chicago, is perhaps the finest store in the world, and at present incandescent lights are used entirely, but if I am correctly informed they are going to change a large part of the store over to Nernst lamps. The matter of color effect, of course, comes in in department store lighting. I am not prepared to say whether the color of the Nernst light or the color of the arc light is best suited for matching goods, although my opinion is that the arc light is better. If, however, a department store desires to furnish suitable accommodations for matching goods properly, they should have separate rooms, with different kinds of lighting, and customers can examine the goods in the kind of light in which they expect to use them.

Dr. A. H. Elliott:—The question of interior illumination from a gas man's point of view has been very ably presented by Mr. Searle, and I do not know that I can say much in criticism of his paper, except to corroborate in large measure what he said. As he was reading his paper and he was talking about the illumination by candle tips, imitation candle tips, it reminded me of the incident of not many weeks ago. I was at dinner in a handsomely decorated private dining room uptown, and there were 16 double brackets, 32 lights, in a room 25 feet long and 20 feet wide. There were also a number of candles on the table, but I can assure you it was quite difficult to see details of the things on the table, such as the outlines in the doilies and other details of the table linen. Each of these burners was consuming, as I estimated at the table, about two feet of gas per hour, so that my friend was burning about 64 cubic feet per hour around his room, in badly arranged and badly fitted fixtures; yet he was a man thoroughly cognizant of gas and gas affairs. When I called his attention to it afterward and asked who installed the fixtures, he said: "Do you know, I never gave it any attention at all; the decorator put those things up for me." I replied I thought I had better send you a man around and have them changed. I sent the man around and he changed them, and the next time I met my friend he said that

it was a revelation—he did not know that he had such a pretty dining room. He was burning about twice the amount of gas there was any necessity for, and he was not seeing the pretty things the architect intended him to see, and yet if he had consulted a gas man, or a man who knew anything about interior lighting, he would have obviated just such an absurd arrangement. It is a fact that decorators very rarely consult illuminating engineers. I hope this condition will be changed.

As to globes with small openings, if there is anything a gas flame needs it is a nice supply of air, not too much, but enough to keep the products of combustion clearly away from it. A lot of old-fashioned globes are not only small, but probably the holder underneath is made of thick metal that still more contracts the opening. The old type of chandeliers retained in many of our best houses to-day, hang on to the old fixtures because they are old,—because they make such cheap things to-day, etc., these are solid brass, which belonged to my grandfather, or something of that kind, —these old type of chandeliers give most miserable results in illumination. If they re-decorate their house the old chandeliers remain. They are sent back to the finishers to be re-finished. I visited a house in New York which has two splendid chandeliers, beautiful pieces of work, great fixtures, fine decorations. I have known these chandeliers to be in place for twenty-five years. I do not know how long previously they were in use, and every once in a while they are taken down and sent to the finishers to be re-burnished, to be re-gilded, and they are put back again into the same old globe fixtures on them.

One important point touched on by Mr. Burnett in his paper, and Mr. Searle, too, in his paper, is something many people do not realize, and I hope some day or other this Society will bring it out in full force, and that is the matter of eye fatigue. Perhaps, those of you who have worked in a dark room taking photometric observations will know what it is to take a sight light, from the sight box and then to look out at a bright light, if only for a second. If you put the eye back on the box again you cannot see the disc. That is what happens to the eye under ordinary circumstances, especially at the present time. There is a constant tendency to give more light and more concentrated light. It is the aim of the maker of the Welsbach burner; it is the aim of the maker of the incandescent electric light. Now, in addition to the contraction of the pupil of the eye, there is something far more important going on in the eye, which is perhaps not generally known. Maybe some of you gentlemen who have paid attention to optics and kept up with the researches of the German physiologists, will know what I mean when I talk of the visual purple. On the back part of the eye, the ends of which are presented to the light, is a beautiful pigment called the visual purple, and the effect of the blue and purple rays of light is to consume that material. Kuhne and quite a number of other physiologists have studied this action carefully. The blue and yellow rays, which are prominent in our white lights, are the most destructive of that particular pigment, and that is more, perhaps, the reason why our eyes become fatigued than the excess of light, for if you use a yellow light, as, for instance, a bright yellow light, it is not so apparent as a bright electric light or a bright Welsbach light. I come to that conclusion from actually working with different lights. I can take a 40 candle-power, round-wick, oil lamp, and sit and work with it for hours, writing and reading, and I will not be fatigued nearly as much as I will if I use an incandescent electric light or a Welsbach light. The reason is not that my pupils are not active, but that the power of regeneration of this particular pigment of the eye does not keep pace with its destruction. I hope that at some time this question will be brought out more fully by some one more competent to handle it than I am. It is a physiological subject, rather than one of interior illumination, and perhaps I have diverted from the subject in hand somewhat by speaking of it.

The President:—It may be usurping the function of the Committee on Papers, but I may announce that at the June meeting of the Society there will be a paper on the physiological effects of light.

Mr. Waldo S. Kellogg:—The statements just made by Dr. Elliott, about the intensity of illumination, appeal to me very strongly. It seems to me that the constant tendency is to have the lights very brilliant and to produce a great effect, but as an architect I hear more complaints that arise from very great brilliancy of sources of light than from lack of light itself. A person working in a room illuminated by brilliant sources of light is apt when he raises his eyes, to encounter brilliant spots of illumination in the line of vision, and then when he lets his gaze fall upon his work he is partially blinded and, too, complains that his table is imperfectly lighted. I know of a recent case where there was a great deal of complaint on account of lack of light in one part of the room. I was reasonably certain that there was not only an abundance of light, but really more light than was needed in that part of the room. In another part of the room was a table not much used, but so arranged that a person sitting there had his back to all the other lights in the room, the light came from overhead and behind. Some rough measurements made of these two particular localities, showed that there was only about one-third of the illumination in candle-feet on this table where the

light came from behind and overhead, as compared with the table at which the men were stationed who were complaining constantly. It was a revelation to the person making the complaint. I believe more attention should be given to the question of the diffusion of the light, getting rid of brilliant surfaces in the line of vision. I think it will do more to make people happy and contented with their condition than any other thing that can be done, with respect to lighting.

Mr. Thomas J. Lytle:—The effective illumination in a room, in my estimation, depends not entirely upon the system of lighting—gas or electric; they are both objectionable if you look directly at the light. Nothing tires the eye more than to look directly at any kind of light, and the impression that most people have in regard to the Welsbach mantle is that they think of it as a glaring white or greenish white source of light, which is extremely objectionable. At the starting of the Welsbach system of lighting this was true, and to some extent is true to-day. By that I mean there are a great many lights and a great many mantles bought by the public and placed in their houses which give this glaring white and objectionable light. It has been the aim recently in all the convention work the Welsbach Company has been doing throughout the country, and in lectures given to the gas companies, to steer the people around the other way—to the use of a yellow or mellow white mantle. It is perfectly possible to supply a mantle which will give a mellow white light rather than the glaring white or greenish white light, which is so objectionable, and it is only a question of a short time when the people will realize it. As an instance: I was in Detroit about two years ago, where they were using the stereotyped mantle, probably more white than mellow, and in speaking of the illumination at that time I mentioned that it was desirable to use the mellow light; but they stated they preferred to use the white light because they thought from a light standpoint it was preferable. The sunlight, and as Dr. Elliott mentioned, the oil light, are mellow lights, and it is our aim to supply that kind of a light. It is not an optical illusion, but a fact, that the white mantles do not actually give as much light as the mellow white mantle. I am speaking of a mantle composed of 1 per cent., or slightly more ceria, and 99 per cent. thoria. The mantles peddled from house to house are usually extremely white. I have gone into this matter at considerable length, to show you that the system is greatly changed, that the Welsbach light is gradually being changed from the glaring white light which you first knew as a Welsbach light, to the mellow white light, the light of the present.

As to the illumination in a room—did you ever go into a very dark cellar with a candle and have to grope your way about, the light seemingly being swallowed up by darkness everywhere? Did you ever go into another cellar, with cement floors and whitewashed walls, and where you could see perfectly with one candle? This is simply a question of interior decoration. Our rooms are very often covered with dark, dull paper, which absorbs probably 90 per cent. of the light, and we wonder why we do not get a satisfactory effect from our lighting. We do not reflect our light—we are simply swallowing it up. We are burning three or four burners or bulbs that are really not giving any good effect. I think the nicest effect in a room is obtained by using the mantle burners, or tinted incandescent lamps, having a light ceiling, and dropping the ceiling to the guard rail seven feet from the floor, thus providing a canopy or reflector over the entire room. If this is a cream or some other pleasing color, the light, either from the mantle burner or the electric lamp, is given back into the room, which is filled with light not hurtful to the eye but very pleasing. I have recently had my own house re-papered in that way, and the effect is truly wonderful. One burner in a room now will give an effect which required two burners before, and the effect is now more pleasing, because the more light used the harder the light is on the eye, particularly if it is an exposed light.

In store window work, I think it is conceded that the source of light should be obscured, and whether or not we should use reflectors, and the type of reflectors to be used, are questions. If you are showing light goods in the window, you should have a dark background, and have the light on the goods, or *vice versa*. In any event, you should certainly not show the source of light. The inverted gas mantle has become quite popular, and while it is probably too soon to give out any decided information, we find the inverted gas light very efficient, six candles per cubic foot. The decorative possibilities are very great. It is possible to cover the light on the sides, and have a decorative globe which is open below, which will allow the light to pass through without striking the eye. There are reflectors of different designs for use in connection with store window lighting, which give very fine results. There is one reflector, in particular, a cone reflector, which we tested for two days, and gave 277 candles directly below the burner. I do not doubt we shall get much higher results. The results from that form of lighting, I imagine, will be very satisfactory from the decorator's standpoint.

I think we all agree that satisfactory lighting is largely a matter of the proper selection of glassware, whether it is gas or electric, and the proper tinting of rooms. It is quite a general practice, both in the

case of gas and electric light, for a solicitor to get as many lights in a room as possible. I am speaking of new buildings, and wiring old buildings. If a peddler comes in to sell incandescent gas lamps, he will try to put on as many burners as possible. That is something which we should try to correct. I think both gas and electric companies should make some attempt to educate their solicitors. You can sit here and decide what is the best way to illuminate a store, but your solicitor goes out and perhaps does it the other way. I was over to New Jersey to-day, and coming back on the boat I saw an exhibit of holophane globes. I think they are very useful when properly installed, but the globes on the boat were installed one-half up and the other half down, and certainly either those that were up or those that were down were wrongly placed. That is something we must guard against. If it is a holophane it should not be turned upside down; if it is a window light, it should be obscured; if it is a reflector shade over a desk, the light should be shaded, and should come from the side or rear.

Mr. Joseph B. Israel:—There is one point not touched on in the discussion, and that is the question of mixed lighting, not only the mixing of gas and electric lights, but the mixing of different types of electric light. That, you will all agree, is a point that must be guarded against very carefully. I do not think there can be any contrary opinion on that proposition. It may be, a consumer properly requires the different classes of lighting, but he should have certain purposes for each, and the lighting should be so arranged in his installation as to restrict each class of lighting to its purpose. I think that for general illumination we should have large units of light. The Philadelphia Electric Company had occasion to illuminate some railroad office draughting rooms and we substituted for the previous illumination the new type of high-efficiency incandescent lamp, and it has given very satisfactory results. The concentric diffuser, in conjunction with the arc lamp, has proven very satisfactory for the recording room of the Booklovers' Library corporation, a room which is very large and in which they employ many young ladies to do their detail work; the former idea of lighting such a room would probably have been to have an incandescent lamp at each table, over each operator; but we find that the substitution of larger units and the general diffusion of the light has proved more satisfactory and less harmful to the eye.

We had not anticipated in Philadelphia the formation of a general society to take up this work, but we found the necessity for such a department and in our company we made it our business to look after these details of illuminating engineering. We did not cover it under that title, but called it "The Commercial Inspection Department," and it has been in existence some years. One point which appealed to me personally in the formation of this society, is in the establishment of cordial relations between the different interests having to do with illuminating engineering, and in particular with respect to the architects and the contractors. We must work in harmony for the benefit of the consumer for the ultimate good of all concerned. To return to the department of which I spoke, I will read a brief extract from a paper we had prepared for a society among our own employees:

"This department investigates the commercial features, irrespective of any electrical or meter conditions. It is immediately under the direction of the business office, and is in charge of an inspector who makes a special study of such conditions as candle-power effect, color and shade effects, etc., covering broadly the entire field of woodwork, wall paper and natural light conditions; consulting the tastes of the consumer, and determining whether the electrical equipment shall form a component part of a study in decorative art, or shall simply fulfil the more practical and prosy duties of throwing light upon the surrounding objects.

"This inspector is in touch with decorators, fixture manufacturers and architects, and does not talk to consumers about kilowatts, volts and amperes. His arguments are along the lines outlined above, in addition to paying particular attention to the candle-power and arrangement of lamps. By frequent experiments he demonstrates the point which he attempts to convey, thus giving to the consumer more satisfactory results, and a proportional decrease in expense by checking all useless extravagance. He goes farther and proves to a consumer's satisfaction that in many cases he may not have been using the light to the best advantage, depriving himself, under certain conditions, of a large amount of illumination by the use of poor shades or badly arranged outlets."

Now, it might seem that some consumers would resent this, but they do not. They appreciate the efforts of the lighting company to give them better illumination. I have in mind the case of one of our most prominent furniture stores, where they repainted the interior walls of their entire building on the suggestion of our inspector, thus showing that they fully appreciated what he said and were willing to go to some expense to carry out the recommendations. In addition, we issued a circular letter, which is headed "The Distribution, Diffusion and Concentration of Electric Light and Its Importance." This was sent to our customers and others. Another letter was issued along the same lines, to architects and electrical contractors. These letters contained recommen-

dations with reference to the arrangement of the electric lights and the appliances to be employed. We feel gratified in the fact that we have especially cordial relations in taking this stand to pay particular attention to illuminating engineering, not only with our consumers, but also with the architects and contractors. These cordial relations are all very well in themselves, but the question of education is also to be considered, and a society like this, bringing the architects and the contractors into association, will tend to educate us all.

I have in mind a large residence in which an elaborate fixture was placed in the dining room—I also dine there occasionally, like Mr. Elliott. There was a large waste of light in this room on account of improper switch installation. This did not touch on the electrical or mechanical end of the business, but was properly a part of the illuminating engineering. There was a center fixture over the table, containing not less than 16 lamps, and when the butler dressed the table and prepared the dinner, he probably used more illumination before and after the dinner than was used during the progress of the dinner. When it was pointed out to the owner of the house that a regulating switch could be attached to the base of the fixture, by which he could control the number of lights used, he was very much surprised, as the matter had not entered his mind.

Mr. John Campbell:—I think we are all gradually coming to understand that a great deal of the trouble in poor illumination has come from the fact that the consumer or user of light has had in the past to depend on the different statements made by the different sellers of apparatus. One particular tip manufacturer or lamp manufacturer would make certain statements and his competitor would go out and make statements that were radically different in order to sell his own goods. Now, in both cases, without doubt, part of their statements were true. The rest of the statements were simply made to sell the goods, without considering the conditions under which they were to be used. It seems to me that the whole trouble with illumination has been that the rule-of-thumb has been used too much—the subject has been considered generally, rather than taking each separate lighting condition and treating it in, and of itself. I had a case recently in laying out some light, and after the work was installed a complaint came from the excessive use of current. Part of the trouble was caused by the switches, and that was easily remedied. Another question was the unit of light and proper shades, and these were very readily remedied. Then the question came up for a new house, and when I mentioned to the parties that measurements could be made to guide in placing the lights, they were very much surprised to find that such a thing was possible. We have a work to perform with the public in making them aware of the fact that the installation of lights is an important matter. They should be made to understand that it is possible to lay out scientifically the plan for lighting a house, and to make this matter more generally understood should be one of the first missions of this Society.

Mr. T. R. Beal:—This is the first meeting I have had the pleasure of attending. I was at a dinner to-night before I came here, at which there were gas engineers exclusively. I got an impression at that dinner that there were very few gas men belonging to this Association. Imagine my surprise, when I come here to-night and find that most of the discussion has been on the subject of gas. I am connected with two companies up the State, combining the gas and electric business. During the last six or seven years my experience has been in both lines of business. I am very glad to hear the discussion here to-night on the gas question, because my sympathies are with the gas consumer. I believe, judging from my experience, that the chief source of revenues for illuminating companies in most of the cities of this State is from the consumption of gas; that is to say, in a given city the greater revenue would be from gas illumination rather than from electrical illumination, leaving out the power customers and the display lighting that the electric light company would have. Gas-light is the light the great majority of people use, the poor and middle class people. With all due respect to our friends of the Welsbach burner, they foisted many modern Welsbach fixtures on the customer that have no apparent relation to the fixtures now in use. A complete change has to be made to have the fixtures look artistic. It is obviously wrong to put a 90-candle-power Welsbach light in a small room. I am very glad to hear from the gentleman who spoke for the Welsbach company that they are trying to introduce a mellow light for domestic use. I have had some experience myself this winter with lighting. I took a furnished house which I rented for the season. On moving into it I found it lighted exclusively with what is called the Kern burner. It was so badly lighted, so brilliantly lighted, so greenishly lighted, that there was danger of my hating my best friend whenever I saw him in the light. I had it changed, and I found that the Welsbach people are now making a small mellow burner which gives perhaps less than half the candle-power of the large mantle, but which makes a very agreeable interior illuminating agent when it is properly used.

Apparently all the people in this line of business are tending toward the same direction—that is, toward a more scientific study of illumination. Early this winter,

before this Association was talked of, we had proposed in the two cities with which I am connected, to start a special department on scientific and artistic illumination for the purpose of advising our customers, feeling it is not the thing to sell them all kinds of gas burners, most of which are used improperly. I think it may be said, for the electric customers—not the larger buildings nor theaters and hotels—but the houses of the wealthier patrons—that they will be artistically illuminated because they can afford to employ special talent, architects and illuminating engineers, if you please; but there is a great opportunity for advising the smaller customer as to what he should use and not leave him to the mercy of any fellow that comes along and has something to sell. I think, however, there might be some danger in the title of "Illuminating Engineer" unless we agree on what we are going to advise our customer. It is not enough, in my opinion, to say what the most efficient light should be, because it is apparent we might recommend a green Welsbach light, or a Cooper-Hewitt lamp—there is the other side to the question, and it seems to me a good thing to have the co-operation of the architects, the people who deal with the artistic side especially, to advise with use. I think we operating men ought to hail with a great deal of pleasure the coming of this society.

Mr. A. D. Page:—Within the last two years there has been great advancement made in reflectors for the purpose of distributing light. Reflectors have been produced which will give almost an even distribution of light in three different ways, according to the intensity required, but up to date there are few fixtures which have been manufactured for holding these reflectors. The fixtures which have been designed to go into stores and houses are largely a mass of brass and glass, in which the light is a mere incident. It seems to me that nothing can be done to establish effective illumination more than closer co-operation between fixture and reflector makers in the design of fixtures that will be artistic, and in making scientific illuminating appliances instead of there being simply a mass of brass in which the lighting has to be much more intense than there is any necessity for in order to get any effective illumination at all.

Mr. Kellogg:—I think Mr. Page's suggestion is very good, and I think it would be excellent if the reflector people would take heed. I think, however, you will find that the fixture man would require at the start that the design of his fixture be taken and the globes, reflectors, etc., be adapted to this design.

Mr. W. D'A. Ryan:—People have become so accustomed to strong light, it is going to be hard to convince them of the advantages of soft or diffused light. I have in a number of cases where illumination was provided—perhaps 50 per cent. more than was actually needed—I heard complaints because the presence of some very bright points made certain objects appear gloomy and the light was not considered satisfactory. The question of the proper color of light, for the illumination of stores, is a very broad one. Take the case of a department store in, say, a seven-story building, the first, second, third and fourth stories to be lighted. If they sell 75 or 80 per cent. of dress goods, they will naturally wish to sell them under daylight; on the other hand, if they are selling evening goods, it is an evening light proposition. Kitchen utensils, etc., such as are sold in the basement, etc., would be best displayed by a yellow light. In furniture stores the furniture will look its best under a yellow light. If you have arcs you are obliged to trim them every 125 hours, and are constantly knocking the varnish off the furniture.

A millinery proposition is a white light proposition. As to the jewelry store, that is open to some discussion. Jewelry, aside from the diamond itself, flattens very much under white light. Turn a white light on any jewelry store, where they have glass cases, and then flash the white light off and put a yellow light on, and the jewelry will stand out much better. It is better to have many small sources of light, particularly to display diamonds. If you expose a light without filtration, the intense illumination striking into the diamond will affect the eye and you cannot tell what you are buying. It is merely a question of intrinsic brilliancy, intensity of illumination on the pigment of the eye, the amount of light concentrated on a point, and that depends on the size of the point.

Evening rooms are probably a good thing in large stores, but of limited application. If you have 50 per cent. of evening goods and 50 per cent. of white goods, the chances are you will be required to adopt a white light. As to window lighting, that requires concealed sources, and the incandescent reflector is pretty hard to beat. It is out of the direct line of vision, and while you may lose a little stray light, at the same time the tendency to produce spots is less than with the cone reflector.

Mr. R. M. Searle:—I wish to refer to a case of eye fatigue which came under my notice last week. There is a literary man in our town who starts in at 7.30 P. M. to edit matter which his wife prepares during the day. She is a rapid writer and writes 100 sheets of matter which the husband corrects at night, light being furnished by a half dozen gas jets, three incandescent lamps and an oil lamp, and strengthened by two pairs of eyeglasses. One night when he criticised the electric company because of lowering the voltage, I induced his wife to let him start off with

the usual number of lights, and when he got wrapped up in his work to turn off one unit of light at a time. The result was that she now has him down nearly to a single unit of light, and he goes on correcting manuscript until 3 o'clock in the morning without fatigue.

Mr. E. L. Elliott:—Dr. Kellogg brought up one point I think is interesting, with reference to the fixture designs, when he said that the manufacturer of reflectors would have to conform his lines to the lines of the fixture makers; in other words, the designer of the optical apparatus must change the optical laws to conform to the quibs and quirks the brass manufacturer chooses to put in his design. It seems to me there is the root of the evil in the manufacture and designing of fixtures in so far as they are unsuitable for the purposes for which they are intended. As a matter of fact, a fixture should be first a mechanical appliance, and second a work of art. If the designing of the fixture interferes with its manifest purpose, it is absurd as a piece of art. Put on as many curves as you please, but do not destroy its use. An oil painting is a good thing, but not on a butter bowl, because it prevents the use of the bowl for butter. About 99 per cent. of the alleged ornamental work of the fixture is wrought or cast metal work hung up there for no useful purpose whatever; and I think when the public taste and knowledge have been increased, in which I hope this society may have some influence, to the project where the user says: "I want such and such illumination and you design a fixture which will give me that illumination without paying any attention to the ornamental part of the fixture, so that we will not be required to bend the light around a corner or change optical laws rather than change the design of the fixture"—then things will be in very much better shape.

DISCUSSION BEFORE NEW ENGLAND SECTION

Dr. Louis Bell.—I feel that the Society should not devote too much attention to electrical illumination, although it is probably the larger interest from the pecuniary standpoint. We should stand throughout for the use of all illuminants to the best advantage possible. The electric light man, the gas man or even the purveyor of oil, can furnish good illumination if his commodity is intelligently used; and if not intelligently used each is severely handicapped. In the early days of electric lighting I am sure that all appreciated the fact that a great deal of electric lighting was not what it should be. The fact was certainly called vigorously to our attention by our gas friend, and for good cause. The same thing is true of gas. There is good gas and bad gas, improperly used gas and properly used gas: but the thing it behooves us to bear in mind as illuminating engineers is that it is our duty to get the very best we can out of every luminant. If we can use electricity we want to know what to do with it; and if we are in a position where we can only get gas or even oil, we want to know the limitations of the material we have to use, just as the constructor of buildings wants to know precisely how best to employ the material which is available; and the thing I want particularly to impress on you is that we have not come to the end of illuminants yet. Perhaps we are only in the beginning. Within ten years there has been almost a revolution in the efficiency of illuminants—certainly in their usefulness. Ten years ago the mantle burner, which is the strongest possible card in the use of gas as an illuminant, was coming into use. It had not been pushed to anything like its legitimate usefulness. Ten years ago, too, we were just beginning to get the better class of arc lights. We have only recently come to the more efficient arcs and more efficient styles of incandescents. This is not the end of things, by any means. We must expect in the next ten years an advance which will cast into the shadow anything which has been done. In the matter of electricity we have illuminants four or five times as efficient as anything we thought of a decade since, in the flaming arc, the mercury arc, etc. In the same way the gas man has pushed the mantle burner from the rather unsatisfactory light of ten years ago to one of very great brilliancy and very great usefulness. Improvements along these lines must proceed, for we have not yet reached the limit in the matter of efficiency by any means. There are a great many sources of illumination of which we have not yet seriously thought. The chemist may have something to do with it. Even the biologist may be heard from yet. I was speaking recently about a clever suggestion that emanated from a New York doctor long ago regarding the piping of oxygen for general consumption as an available material for forcing oxidation and obtaining very high temperatures and immense intensities of light. With our present resources something of that kind may arise to bring illumination up to a higher basis. The vacuum type of light, with its extremely interesting possibilities, has only been touched upon as yet—hardly enough to be considered seriously. So we shall improve steadily. We cannot sit down and rest on the incandescent and arc and consider these as the ultimata; we must keep pushing ahead on new methods, and the engineer in years to come will have before him, and only a short distance ahead of him, a much richer field in materials than he has ever had. But he must handle even the best of them with consummate skill in order to obtain the best result, and I be-

lieve the energies of this Society can be best directed perhaps to educating the users and installers of light to appreciate what good illumination is, and in the utilization of material systematically so as to produce this. All those who sell illuminating material have suffered at the hands of the installer and user. The best thing we can do is to get at the people who use the light and show them how, by careful attention to details, they can get the very best results from the material which is put at their disposal. In the long run it would pay. The man who can get effective illumination for two-thirds the expense to which he has been accustomed is not going to cut down his bill but hold steady. The immediate result of a good and cheap light is a call for more light. I do not know of any way in which that has been more effectively shown than by the coming of electric light into the gas field. Each has helped the other, and every improvement in each has, by making better light for the user, built up a demand for the very articles that many of us are selling. The man who is able to get two candle-power where one was to be obtained before is doing good service. I am impressed with the importance of getting at the men who design the fixtures and the user of the light and showing him how to make the most he can of what he has. There is another side—the artistic side—which must not be forgotten, and which is often passed by as of secondary consequence. One does not have to go far to see some horrible examples of inartistic and thoroughly bad illumination. Sometimes this is noticed and remedied; sometimes it is not. The delivery room in the public library in the city of Boston in its early stages was perhaps the most shining example of the mal-application of light that I have seen. In that room the mural paintings are sunk into deep panels, the reason for which I have been unable to discover. That room was originally lighted by two gigantic chandeliers which came down one third of the way to the floor, and were bottomed with incandescents, entirely defeating any object of lighting up the mural paintings and in fact preventing anybody from seeing them. That was finally remedied, but even when it was done, it was not done well. If you will go there to-night you will find that the lights intended to illuminate the paintings are not directed so that they do it to the best advantage, for the very simple reason that the scheme of decoration which had been adopted for the room, utterly irrespective of the possibility of having paintings there which anybody might want to see, was such that it did not seem wise to put the lights where they would do any particular good. It is that sort of thing which ought to be given a great deal of careful attention. We want to know not only how to get good light for general illumination but how to use it for particularly illumination, as in a case of that kind, with the best benefits possible. I might say that almost every public building shows a lack of that in the adjustment of illumination—in fact, shows absolute lack of anything except a desire to show off the fixtures. It is largely the fault of the designer that we have so much bad illumination, and it is that phase of the matter which the Society can take up to great advantage, and I hope that some of our friends who are economically watchful from the artistic side of illumination, will very soon give us a paper on the subject, dealing not only with the general points of illuminating, but with the particular kind of illumination which is desirable for the purpose from the artistic standpoint. The weak side of such studies heretofore has been that more attention has been paid to the fixtures than to the effect of the lights.

Mr. W. E. Holmes.—In the city where I live there is a great deal of poor illumination from both gas and electric light. While I am connected with a combination company, and while we are fighting for business right in the same office, we lend a helping hand where the other fellow can get business and we cannot get in. We favor each other as much as possible, but if there is any business there that we can both get in, it is a fight to the finish. On the matter of house illumination, there is a good deal to be done in educating the householder, and the way to get at it, I believe, is to start at the first with the new house. The old householders are hard to get started. It is hard to make them do anything. They think we are thieves and robbers, and we have been received in many of these houses with a great deal of suspicion as to our intent with them. When we first went into a man's house and said we came there in his interest and wanted to look it over and help him, it did not go at all, and it took several visits before the man really would allow us to do anything. He thought from what his neighbors had told him and perhaps from what he had seen in the old days, that we were trying to get a little more money out of the installation. That still holds to-day. We find it right along, but I will say there are customers who, after we meet them several times, and especially if we can get them to go with us and see another installation, will give us the credit of working a little in their interests. I do not want anybody, however, to think it is not uphill work to make these people believe that you are willing to do anything for them in their homes in the way of reducing their bills or giving them more light for the same amount of money they are paying. We are hard at it. The competition there between the electric light and the gas is pretty fierce. The customers are perhaps captured by the gas

man first and then the electric man will get after him. That competition is good. It is first class for the solicitors—the men who are doing the work—but our solicitors all have strict instructions to present the matter right and put the company in the right light before the customers.

Mr. W. E. Clark.—I think that all connected with illuminating industries should be equally interested with the consumer in making illumination most effective. If the customer makes a complaint and is ignored, he will be apt to change from one illuminant to another. It should be seen to that the customer has the right kind of shades, right kind of lights, and that the latter are so disposed as to give the best lighting effect. We very often see electric bulbs so covered with dirt that perhaps half of their illuminating power is lost, and in such cases customers should be advised to have them cleaned. I join with Dr. Bell in suggesting that the Society have as early as possible a paper on the illumination of rooms and various kinds of halls, churches, etc., from the standpoints of efficiency and economy and also from the artistic side.

Mr. E. R. Brown.—There was one point that occurred to me in hearing Mr. Searles' paper, and that is the matter of renewal of lamps. When we first started out to give free renewals we were looked upon as bunco-steerers or something of that kind. We considered, however, that the better light a man gets the more business he can do. Partly on our recommendation and probably more from appreciating that it was good business policy, many stations started in with a free renewal of incandescent lamps. I want to speak of the experience of the Hartford Electric Light Company. Those of you who know Mr. Dunham realize that he is one of the most progressive and virile men in the United States. He does not satisfy himself with giving free renewals of lamps from the office, that is, with people coming in with half a dozen lamps and getting half a dozen others in return. He first started around a cart with lamps. They called at the house of the customer and asked if there were any lamps which could be renewed. Since then many others have done this. Mr. Dunham is now pursuing a course which is much more effective, I think. The inspector goes into the house, goes into the different rooms and takes out the lamps which are dim and suggests what lamps should be changed, and it is the practice of the Hartford Company not to let any lamp burn more than three or four hundred hours. In that way the Hartford Company are using about two lamps for every person in Hartford, which, so far as I know, is a greater proportion of lamp renewals than in any other city. I believe this same thing would pay the gas company. I have been in a great many houses and places of business where the gas mantles were not giving one fourth the proper illumination. If a gas company can get the confidence of its customer, can go into the customer's house and renew the mantles free or at a moderate charge—I think this part is immaterial—directing the customer's attention to the fact that the mantles are not efficient and that he is taking the same amount of gas and getting only a small amount of light—I think it would go a long ways toward increasing the use of any illuminant. I think that practice is one which would make every electric light company in the United States in a great measure as successful as we all know the Hartford Company is to-day.

Mr. E. N. Wrightington.—In listening to Mr. Holmes on the question of getting customers to use the best illuminant they can in the most efficient way, it occurs to me that I find that unless the customer feels that the bills are high it is practically impossible to get them to change to a more economical and more effective method of illumination. But I think we can educate the public up to that sort of thing, and I think this is shown by the fact that the standard of illumination at present is 100 per cent. higher than it has been; that is, the ordinary man sees better light used and is accustomed to using better light. The stores are better lighted and the general standard of illumination is far higher than it ever was before, and I believe that by educating the public up to the idea of better house and store illumination we can accomplish the same result there. The question of renewing gas mantles and electric lamps, is, I think, a very important one. In our experience we find that the mantle lights when cared for by the customer give a great deal less satisfaction than if cared for under contract. It is impossible for the gas company to maintain mantles free of charge, but by making some nominal charge, as we do in the case of gas arcs, for renewal of mantles and care of lights, we find it gives a great deal better satisfaction, and that has led to our making a lower charge for arc lights where care and maintenance is given, after the first year. The lamp will be sold cheaper if the customer will allow the lamp to be taken care of. I should like to see some data on the effect of lighting with gas and mantles in various ways. Dr. Bell has spoken about it, and the whole question is one that needs to be threshed out carefully.

Mr. Brown.—I would like to ask why it is impossible or impracticable for the gas companies to renew mantles without charge?

Mr. Wrightington.—It is simply a question of price. Of course, in the case of electric light renewals, the price practically includes that. In the case of gas the cost of maintenance would be so much that it would cut down the profits considerably. The present price is 60 cents a month or

$7.20 a year for an arc, and while it does not cost $7.20 to maintain it, it costs very nearly that, and it would cut out the profit on the lamp very materially.

Mr. Brown.—Why not give the customer free mantles instead of reducing the price of gas, when the time comes for such a reduction? That has been done by electric light companies—giving the customer free lamps in lieu of a reduction.

Mr. Wrightington.—I am afraid that would not appeal to the man who is kicking for the reduction.

Mr. Brown.—It worked all right in the case of the electric companies.

Mr. Wrightington.—Yes, but it is a different kind of customer that you have to deal with there.

Mr. Brown.—Then is it not up to you to educate that man?

Mr. Wrightington.—Yes, it is, but it is very difficult to make them use mantles.

Mr. Brown.—Do they not have a portable meter, and will it not convince a man when you show him that the mantle burns only three and a half feet while the other burns five?

Mr. Wrightington.—We can do that in individual cases, and it seems to be the proper thing to do; but if the customer is satisfied, it is pretty hard to go into all these details with him. I think it would be very difficult to satisfy the ordinary consumer by agreeing to allow free renewals instead of a reduction in the price of gas.

Dr. Bell.—I would like to ask how much has been done in the way of progress with a mantle of relatively small capacity? Most of us who use mantles are more interested in getting say 25 c.p. on one and a half feet of gas than we are in getting 100 c.p. on five feet of gas. It has always seemed to me that if the gas mantle in smaller sizes were successfully worked, so that the light would be distributed a little more successfully, it would make a very great increase in the use of them. I would also like to ask about the reports I have seen in some technical papers about improvements which have gone to some length toward obviating the greenish color in the older mantles. These are two very practical questions.

Mr. Wrightington.—I would say that the old method in the case of a chandelier, say, was to put in a single mantle to replace two or three lights in the chandelier—to use one light for lighting the whole room. We have tried to educate the public up to the point of using small units and more of them. We have now a perfected form of Bunsen burner. It is a small light, less than a three-foot mantle in place of five feet in an open burner. It is a light similar in appearance to the electric incandescent light and is, I think, for residence lighting the best form I have seen, and it allows a better distribution of light around the side. On the question of the color I hope that the Illuminating Engineering Society will get to that point, and that we may have a technical paper on the subject. I think the present mantle is an improvement over the old form having a greenish appearance. I do not know how it has been accomplished, but I think it has been at the expense of efficiency. It would be preferable, to my mind, to get it even better than it is at present, even at the sacrifice of some efficiency, because the light is cheap enough. We can afford to lose something there.

A Member.—Possibly some of you may not have seen the new type of inverted gas burners. We received to-day and are putting in place for display purposes, a number of very small inverted burners, encased in small globes, somewhat smaller than the lamps in this room, and we get very beautiful effects. Some of the globes are tinted. As I came down here this evening, I could not help being impressed with the fact that stores on Hanover and Washington streets were lighting up the sidewalk more than their windows, and you were dazzled by the light. I never saw anything prettier in a lighting effect than that in Marshall Field's windows in Chicago. There were very few goods in the window and they were placed with care, and the lights were entirely from above. In one window was a display of neckwear, carefully selected as to both color and arrangement, and you could not help admiring it.

Mr. John Campbell.—The question spoken of by Mr. Wrightington of figures for the different forms of illumination, is a point that the Boston section should take hold of, and if need be, go so far as to appoint a committee to investigate and report. One of the objects of the Society should be the education of the public, and to show them that there is one society that can be relied upon for accurate and absolute knowledge. Of course, there are such societies at present, but there is no other one devoted entirely to illumination, and there is no one subject quite as broad as illumination, and no subject on which there is such a lack of scientific practical knowledge. There is an immense amount of scientific knowledge, but a fair share of it is not practical knowledge—that is, knowledge that can be adapted to the practical use of the light.

A Member.—I think everybody realizes that there is a great deal of lighting that is anything but good, and people are beginning to realize that there is a difference between good lighting and poor lighting with the use of the luminants which we have. The more we look around in a critical way, the more we realize that there is a broad field for us to work in, and I think it is going to be a great benefit to everybody to get together all possible information and compare notes, and for this reason I

believe this organization will be a good thing for us all.

A Member.—I heard one gentleman say something about open flame burners, and he mentioned the way in which the different burners waste gas. I have found a lot of people who use aluminum tips, and they get very good results from them; they are economical lights, burning only about 4½ to 5 feet of gas. The only advantage of a Bray burner is that it will not burn any more. With an aluminum tip you may burn more, because if you give it full play it will burn 11 or 12 feet of gas, and then the customer comes in and kicks about his bill. That is the only reason why I advocate a Bray burner, because I know the customer cannot use so much gas with that burner, and will be satisfied. I think the inverted mantle is a good thing. If a man has goods in his window and uses gas, he is afraid the lights will set his goods or his draperies on fire. Now with the inverted mantle that danger will be done away with. anything that is up on the ceiling cannot catch so easily, therefore I think the inverted mantle a very good idea, and one that will be profitable as far as the illumination of windows is concerned. Another gentleman remarked upon the store keepers in Boston illuminating the sidewalks. I have found that unless you illuminate the sidewalk you will not get the people to stop and look in, no matter how much you illuminate the window. They will not stop for that, but if they see a light in front they will stop and look in. That is the reason it is done. You will see in the stores that they have more lights in the window and around the sides than necessary. It is because the more light that is put out in front of the window, the more people will stop and look in. The average business man is not looking for the education of the public, but for the increase of his bank account, which is more important to him. In regard to the replacing of gas mantles, I think the majority of the consumers of gas live in tenements, and in many cases—in fact I think in seven out of ten cases—a mantle in this case is impracticable for both the consumer and the gas company. Most of these consumers have small children who jar the mantles and smash them, and if the gas company is to supply them free of charge, it will mean keeping a man outside of each house with a basketful of mantles. I am talking about certain sections of Boston with which I am acquainted, but I think that would apply anywhere where there was a tenement house. If anybody can invent a mantle that will not break, I think there would be money in it.

Mr. Clark.—I would like to say one word more. While it may be true that if a sidewalk is brilliantly lighted, it will make a person stop and look in the window more quickly, still I think, especially with electric lights as we see on Washington street, where rows of lights are put in as they are, that it is an extremely expensive form of lighting; and if the same or a lesser number of lights were put in at the top of the window out of sight of the public and with powerful reflectors above them, the window would be much more attractive, and would probably have about as much effect on those passing, while those who look at the artistic side would find it a very much more pleasing window. There is also the effect of the light on the eyes. Rows of lights in plain view are extremely trying to the eyes, and a great many object to them. It is trying to the eyes of a great many to have the lights hanging as low as they do in many center chandeliers. I think papers would be of great benefit discussing halls, buildings, rooms, etc., that are poorly lighted now, and the way they could be improved.

Mr. Campbell.—Along this line comes the question whether the people do not for outside lighting use a trifle too much light, more particularly in New York than in Boston. Down there it is getting so that the theaters and certain classes of houses are using the luminous arc. They certainly make a flaming advertisement. The light makes the ordinary light look like a tallow candle. At the same time this luminous arc, when placed at the present existing height, is a very trying light on the eyes. If it was raised up I think much better results could be obtained, but that is a matter of distribution of light rather than increasing the amount of light. Referring to Mr. Searle's paper, in a certain case I told a party that he ought to wash his globes and shades. The porter did this, and afterward the man called me up and wanted to know if I had put in new globes and shades or new mantles. It was simply a case of an accumulation of dirt. The public do not realize how much their bills are increased simply by lack of care. They seem to think the lights will take care of themselves after they are in. I know that in the electrical field some people pride themselves on the length of time they burn their lamps, and feel quite indignant if suggestions are made that it would be well to renew them. The Welsbach light is a matter we are all interested in. The smaller units will certainly be a vast help.

Mr. Holmes.—There was one point that Mr. Clark touched on which I am interested in. That is the reflection. We have found lots of cases where we could induce the customer to use reflectors by telling him that he could get just as much light or better with half the wattage in that window that he had before. We are pounding into our solicitors the advantage to the customer of reflectors—proper reflectors and properly used. I could show you windows with Welsbach burners set on a line of pipe

with mirror reflectors over them, giving an elegant light. I know of another window without mirror reflectors, and the light does not begin to compare with the first-mentioned window. It is just the same with the electric light. If we can induce the customer to spend a little more money for reflectors and a little less for current, he will be a better satisfied customer in the end. I think there is more in that than a good many of us realize. There is one other thing I want to speak of. This is not a place for us to fight about another man's goods, but somebody spoke of the inverted mantle burners. We have in our office and we have in a certain restaurant in town, some of these inverted mantle burners, and the electric light solicitor considers them one of the best advertisements for the electric light for the reason that every one of these pretty little brass fixtures are all smoked up from the ascending fumes of the gas. I have seen our electric light solicitors take customers right around in our office and show them the inverted mantle fixtures with the little shade holders all smoked and the little brass gooseneck all blacked, as in the restaurant I mentioned. I am not a gas man, but the fact remains that the electric fellows consider the inverted burner a good advertisement for the electric light.

Abstract of Papers Presented at the Meeting Held in New York May 17th

A METHOD OF STREET LIGHTING BY INCANDESCENT LAMPS

By Western Underwood and V. R. Lansingh

It has been suggested many times that it might be possible to light effectively the business sections of cities by means of incandescent lamps, and in a number of cases this has been tried with more or less success.

The ordinary method of lighting streets by the use of arc lamps is open to numerous objections, chief of which is the glare, which exists even when opal globes are used. Where an opal inner and clear outer globe are used, the resulting glare is so great that it is practically impossible to see anything beyond the lamps, especially if hung low and rather far apart, as is generally the case

Incandescent lights have been used in lighting outlying districts with considerable success, and to the driver such light is far preferable to arcs placed farther apart. Any one who has driven a horse or automobile down a street lighted by arc lights, and down another street lighted by incandescent lights, will appreciate the above conditions.

Attempts have been made to use incandescent lamps for lighting the business sections of some cities, notably in the case of Columbus, Ohio, where strings of incandescent lights have been placed on arches across the street. This gives fairly good results, but is open to some of the objections which apply to arc lighting. In the first place, such arches generally have more or less of a festive appearance, and lack dignity. Secondly, bare lamps are used which, while producing a light less trying than the arc, is, nevertheless hard on the eyes of a passer-by. A third objection is the inefficiency, a large proportion of the light going upward.

Another method is that used in Los Angeles, Cal. In 1895 the merchants located on Broadway of that city, started the "Broadway Improvement Company," for the purpose of improving the street lighting. At that time, it was lighted by arc lights placed at the intersection of cross streets. As the blocks on Broadway are nearly 600 feet long, the illumination midway between lights was almost negligible and the actual street light was furnished practically entirely by the shop windows.

The leading spirits of this Broadway Improvement Company were Messrs. F. W. Blanchard, Wm. Sny-

der and Major Norton. Their argument in improving the lighting of the city was, that better lighting would attract more trade to Broadway and would raise the standard as a whole of the lighting of Los Angeles. The money for making these improvements was raised by subscription, the assessment being $1.50 per front foot, it being the intention at the start for the owners of the property to pay for the installation of the lighting system, the tenants to pay the operating costs. Later the entire installation was turned over to the city as a gift, with the understanding that the municipality should pay for the lighting, the Electric Light Company furnishing light, renewals and globes. The designer and superintendent of the system was Mr. Western Underwood, of the firm of Messrs. Forve, Pettebone & Company, a local fixture house.

The system as finally adopted, is indicated in Figs. 1, 2 and 3. It consists of ornamental poles placed on an average of 100 feet apart, each pole being directly opposite the one on the other side of the street. The lights are all placed upright, which, while undoubtedly not quite so efficient as if placed in a pendant position, nevertheless renders the liability to breakage less, and in case of breakage protects the passer-by from falling pieces of glass. Fig. 4 shows the type of post used on Broadway. The center ball is of ground glass, roughed on the inside, 18 inches in diameter, containing six 32 candle-power lamps in two tiers. Surrounding this arc six eight-inch balls with one 32 candle-power lamp in each. All lights burn from dark until midnight, after which hour the lamps on two of the four posts at corners of the street are turned off. The voltage is 110. One of the difficulties in the first installation was the effect of the sun in the day time rendering the iron posts so hot as to cause trouble with the rubber-covered wire used. This has been rectified since by the substitution of asbestos-covered wire.

FIG. 1.—BROADWAY AND FIFTH STREET.

In all there are 134 posts on Broadway, covering a distance of 10 blocks in the heart of the business section. The cost of each pole set up complete was $100.00.

One of the difficulties of carrying out successfully this plan was the refusal of a number of property owners to pay their assessment, resulting in a deficit which had to be made up by the more public-spirited. As it was desired to extend this system of lighting to other streets in Los Angeles, the parties interested had a law passed

FIG. 2.—LOOKING DOWN BROADWAY.

by the State which allows the City Council to make an assessment of properties in the district benefited, and requiring the signature of two-thirds of all property owners interested, in order to prevent the adoption of the plan. This, of course, opened up a way by which other streets could be similarly provided, and Spring street, Hill street and others have taken advantage of the opportuity, and contracts have been let for lighting almost all the entire business section of the city with this system.

The type of post adopted for Spring street is shown in Fig. 5. It has four arms with 12-inch roughed inside balls with three 16 candle-power lamps to each, and one large center ball 16 inches in diameter with six 32 candle-power lamps. On Spring street there are 134 of these posts, and on Main street 164. As will be noted in comparing Figs. 4 and 5, the posts adopted on Spring street are more ornamental than the other type, but the lighting effect is not so good, owing to the fact that the large 12-inch balls considerably shade the others, which is not quite so noticeable in the case of the Broadway installation.

As will be noted by Figs. 1, 2 and 3,

FIG. 3.

the illumination of the street is remarkably uniform. In no case is the lighting really brilliant but, as will be seen from the cuts, the lighting is extremely good and very easy on the eye. The advantage gained in this respect by using roughed inside balls is very considerable. Where the globes have been broken and the bare lamps are visible, the trying effects on the eyes is extremely noticeable; and while there is undoubtedly a reduction in the total amount of light, the ability to see well is greatly enhanced by the use of these balls. At the same time they make an extremely ornamental and dignified appearance, with the result that the amount of business on the streets so lighted has, it is claimed, been greatly augmented.

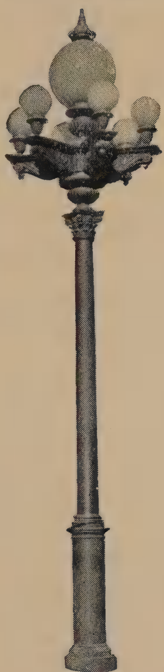


FIG. 4.

FIG. 5.

FIG. 6.

The photographs shown here, which are untouched, were given exposures of from five to 15 minutes. It will be noticed that there is very little halation, and that the light at all points is remarkably uniform. It is possible to stand half way between the posts and read the print of an ordinary newspaper; even when placed horizontally. When held normal to the eye a newspaper can be read with ease. It will be noticed in examining the cuts that not only the street itself is well lighted, but also the buildings, giving an extremely cheerful effect to the entire street.

Perhaps the chief objection to the whole system is that too much light is thrown upward, and that therefore the system is not as economical as might be desired. Experiments are now being undertaken to see if it is possible to overcome this defect. If this can be done, an increased illumination can be given in the street at the expense of some of the upward light; or as the illumination of the street is ample at present, it will probably result in a reduction of the current used, by employing lamps of smaller candle-power.

So successful has the system proved to the public in general, that many other cities are considering the system, notably Pasadena, California. There a similar system of lighting has

been adopted but the posts are provided with 12 arms, in a pendant position, giving a sort of spray effect, with a large upright globe in the center. Each of these arms is provided with 16 candle-power lamps, with six-inch balls. The illumination from these posts will be undoubtedly better than if they had been upright, but the posts are not as ornamental or dignified as those used in Los Angeles.

In Chicago, Michigan avenue is partially equipped with posts similar to those in Los Angeles, but of a very uneconomical design. They also lack the artistic features so noticeable in Los Angeles.

In San Francisco the movement was taken up by the citizens, and about ten posts installed as samples, it having been the intention to adopt a similar scheme of lighting on the principal business streets. Propositions to the same end are now being considered in Seattle, St. Louis, Denver and Salt Lake.

This system of lighting by incandescent lights seems to be meeting with very hearty approval throughout the West. The chief advantages are that the illumination of the street is remarkably uniform, the glare is practically eliminated, with the result that the ability to see clearly and comfortably has been largely increased. The street gains dignity in appearance and furthermore trade, as has been actually demonstrated, is directed to a street so lighted.

Practically the only objection is the cost of the operation. As installed in Los Angeles, the consumption is practically 12 amperes at 110 volts per post; and as the posts are directly opposite each other, and on an average of 100 feet apart, this means 12 amperes at 110 volts every 50 feet, or practically the cost of operating one arc lamps of six amperes every 25 feet.

It will be noted that in Figs. 1 and 2 there is a bright streak down the center of the car track. This is due to the arc head light on cars, within the field of the photographic lens.

LIGHTING OF STREETS BY THE INCANDESCENT MANTLE BURNER SYSTEM

By F. V. Westermaier

To make it possible to produce practical results, it was found necessary to design appliances which could be easily handled and taken care of. The old style of gas lamp with tin frame, plain glass sides and no bottom, and with a tin cup for a top and ventilator was soon discarded for a lantern built on more beautiful and practical lines. A substantial cast-iron frame of neat design surmounted by an opal dome with an efficient ventilator, a cylindrical glass globe closed at its bottom by an adjustable plate with means for opening to light the burner, became the recognized type of street lamp. This lantern was designed to be at once dust, draught and insect proof. Care was also taken in its construction to afford means for the changing of parts and for the adjustment of the burner.

At first the ordinary type of house burner was used, but it was soon learned that with the conditions to be dealt with on the street, *viz.*, dust, vibration and variation of the gas pressure, a different style of burner would have to be developed. The present form of burner is the result of years of experience and experiment. By a lock-lever attachment, a climbing lighter pilot is first lighted, and this in turn lights the mantle, being itself then extinguished. This burner is designed to afford positive regulation and to produce the highest efficiency for the gas used.

The essential part of the appliance —the mantle—has been evolved after long series of tests. In order to withstand the rough usage on the streets, it has been found necessary to construct a mantle especially for street lighting purposes. These mantles are strong in structure, and, owing to special treatment and preparation, retain their candle-power efficiency longer than the average commercial mantle. The mantle was formerly supported by a single wire over the

burner gauze, but they are now mounted with a double wire support on individual gauzes, so that with each mantle there is a new clean gauze. The mantles are capable of producing from 20 to 24 candles to a cubic foot of gas of a thermal value of 600 British thermal units; while, with gases of higher heating value, such as natural gas, the efficiency rises to over thirty-five candles to the cubic foot. In dealing with natural gas it is necessary that the mantle be specially treated to prevent the percentage of cerium being reduced. This treatment is most important, as without it the mantle loss would be very high and the service would not be efficient.

All mantles have color, the most objectionable being those with the greenish tinge so often seen. By numerous tests it has been found that the slight orange shade produces by far the best results.

In the street lighting of cities it has now become a recognized fact that the two systems of lighting, *i. e.*, the electric arc and the incandescent gas, have each its own special value. The street lighting of New York is an example of judicious arrangement, with its broad avenues lighted by arcs and its cross streets and Central Park lighted by mantle lamps. Intense illumination, such as produced by the electric arc, is neither desirable nor necessary in residential sections. The incandescent mantle lamp diffuses its light over these sections to much better advantage.

In the installation of incandescent gas street lamps it is very important to determine the existing pressure conditions. Very often where the topography of a city is hilly, and where also the gas mains are of insufficient size to supply the ever-increasing demand, the pressures at the lamp posts are very irregular. With extreme conditions, where the pressure varies more than 1 inch of water, the efficiency of the incandescent gas system would be very much affected if means were not provided to take care of such fluctuations. The latest development has been an efficient gas controller which, with pressures varying from 1.5 to 4 inches, supplies a uniform amount of gas to the mantle. This appliance has proved its value in a number of cases that have come under my observation. After being in service for months, controllers brought to the laboratory to be tested under varying pressures are always found to operate perfectly.

In order to maintain the efficiency of the incandescent gas street lighting system, it is absolutely necessary that the lamps receive proper care and attention. As each lamp is in itself an individual plant, it must be adjusted to suit the conditions under which it operates. Lighters are not given any more lamps than they can properly care for, and are held responsible to their respective inspectors for the cleanliness, efficiency and adjustment of the lamps on their routes.

A number of patents have been issued in the United States and abroad for automatic devices for lighting and extinguishing street lamps. The methods employed can be divided into three classes: 1°, Electric, similar to the house push-button appliance. 2°. Clocks on each lamp. 3°. The raising and lowering of the gas pressure in the mains from the gas works. Each patent has some particular feature of its own, but the majority are impossible for practical use. Tests have been made of different systems, but the results have not been satisfactory. The practice of granting short-term contracts for incandescent gas street lighting prohibits the enormous expenditure necessary to have independent mains for street lamps; therefore, the majority of automatic devices could not be used even if they were perfected.

There is no doubt that the best possible service is to be had only where each individual lamp receives daily attention. Manual lighting will therefore not be replaced by the automatic unless great improvements are made.

In England and on the continent

there are a number of self-intensifying incandescent gas street light systems competing with arcs. It is almost impossible to get any really authentic results as to their comparative efficiencies. In this country self-intensifying gas lamps for street lighting purposes have not proven successful, the reason being that the conditions under which they are compelled to work on the street affect the mechanical apparatus, and they soon get out of order.

The mantle burner system of street lighting can also be applied in those cases where it is impracticable to extend the gas mains. Gravity feed gasoline lamps are then used in connection with a burner of special construction. This form is extensively used in park lighting, giving excellent service, the candle-power obtained being about the same as the gas lamp.

Without a perfect system for taking care of mantle lamps, incandescent street lighting would fail. It is absolutely necessary that the lamps be regularly inspected, the globes and domes kept clean, broken mantles replaced and the entire lamp kept in good condition.

As I have said before, the mantle burner system of street lighting has its place in municipal lighting as well as the electric arc: and together they form as perfect a system of street illumination as it is possible to produce.

HIGH EFFICIENCY INCANDESCENT LAMPS FOR STREET LIGHTING

By Francis W. Willcox.

Incandescent lamps used in series form a simple and efficient method of lighting streets in small towns and suburban localities, and in fact all places where the result is to be obtained at a minimum expense, and where the conditions do not permit the use of high candle power lamps of the arc type to obtain the desired illumination.

Incandescent lamps have obvious advantages in street lighting work as they can be made in low candle power sizes and distributed at frequent intervals, thus securing a very uniform distribution of light as compared to the passing of greater total candle power at greater distances apart as in the case of higher candle-power illuminants. Until the last three or four years the use of series lamps for street lighting has not been altogether satisfactory by reason—

1st. Of the lack of efficient and reliable devices for the automatic regulation of current.

2nd. Of unsatisfactory apparatus for automatically cutting out the lamp on breakage of filament, and

3rd. Unsatisfactory and inefficient incandescent lamp in the candle powers, ampere and voltage ranges required for this class of service.

As regards the regulating apparatus the various devices employed for are familiar to all central station managers and need not be described here. Sufficient to say that the bank board, the shunt box, the hand control reactive coil and similar devices has given way to the constant current transformer. This excellent device automatically insures such a uniform and well regulated service that satisfactory life can be obtained from lamps of relatively much higher efficiency than could be previously used. This improved regulating apparatus has therefore assisted to definitely establish street series incandescent lighting on a satisfactory basis.

Similarly in the automatic cutout of the lamp material improvement has been made by removing cutout from the base of the lamp to the socket and with the adoption of higher line voltages has insured a more certain action of the cutout film by which burned out lamp is short circuited and the current maintained uninterrupted.

The incandescent lamps used for street series lighting have not in the past been altogether satisfactory due to a number of conditions, the lamp being a difficult one to manufacture owing to the heavy currents employed.

In justice to these previous lamps, however, it should be noted that their results would have been materially better had they been with modern constant current transformers and that, as bad as the lamps appeared to be, most of the troubles were caused by bad service conditions.

In recent years material improvements have been made in the quality of street series lamps so as to enable them to withstand the rigors of the service and the price of the lamps has been greatly reduced so that the economy of series incandescent lamp service has been materially improved from the lamp standpoint.

THE NEW HIGH EFFICIENCY SERIES LAMP.

The most remarkable improvement, however, has been achieved in the past year with the discovery and development of the new General Electric Metalized or GEM filament and its application to street series lamps. The benefits of the metallizing process apply particularly to lamps of the street series types which are in general lamps with sufficient thickness and size of filament to realize the full measure of improvement which this process can give.

This metallizing process was discovered by Dr. Whitney of the Research Laboratory of the General Electric Co., Schenectady, N. Y., and was developed by the Laboratory at the Lamp Works, Harrison, N. J., and fully described by Mr. J. W. Howell, Engineer of the Edison Lamp Works at the annual meeting of the Institute of Electrical Engineers at Asheville, N. C., in 1905. The particular effect of this process is to make the filament much more refractory and thus to withstand a higher temperature for a given rate of deterioration. This enables the filament to give a greater amount of light per unit of surface and thus operate at a higher efficiency. In the case of the usual type of street series lamps this improvement appears to be about 30 per cent. in efficiency. This means that the metallized filament street series lamps can be made of an efficiency of 2.5 W. P. C. equal in life for any given candle power to that of the present 3.5 W. P. C. This is the material gain of *one* watt per candle and we can probably appreciate it more fully by reference to curves and accompanying diagrams.

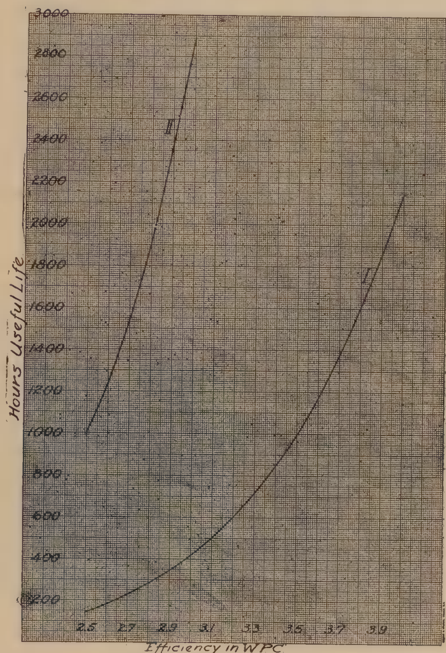


FIG. I.

The curves show the life performance taken to about 75 per cent. candle power at various efficiencies for the new and old filament. In the case of street series lamps the improvement in life values is graphically portrayed. The improvement secured by the metallized filament appears to be largely due to reduction in blackening. As is well known the change in candle power of incandescent lamp is due to two factors:

Change in resistance of filament.

Blackening of bulb.

In the ordinary carbon filament the proportion of the loss of light due to these two causes is as follows:

Due to blackening 55 per cent. of the loss.

Due to change in resistance 45 per cent. of the loss.

On the new metallized filament it is estimated that this loss is proportioned as follows:

Due to blackening 20 per cent.

Due to change in resistance about 80 per cent.

The change of candle power of a lamp for series work due to change in resistance should theoretically be corrected by the automatic increase of voltage by which current is maintained constant through filament.

On this basis the new series lamp (with 80 per cent, of its loss in candle-power due to change in resistance) should develop more than the present lamp, the ideal characteristic of a rising candle power life curve. To illustrate this point I will call attention to Fig. 2. The rising candle power curve is actually given with lamps of 1 to 2 amperes, but for some reason does not develop with lamps of higher amperages.

Street series lamps, life and candle power curves, however, show a tendency to hold up; for, with a given life to 80 per cent. of candle power—the life to 70 to 75 per cent. of candle power is four times as long. This suggests the use of a lower percentage limit for useful candle power—70 per cent. to 75 per cent. instead of the 80 per cent. value used for multiple lamps. The relative brilliancy of the new lamp would permit this particularly as the blackening at 70 per cent. is less than for present lamps at 80 per cent.

In developing the new GEM filament street series lamps the question arose as to what efficiency it was desirable to adopt for this lamp for general conditions of central station service. At the present time there are two efficiencies for street series lamps, namely, 3.5 and 4 w. p. c. The 4 w. p. c. efficiency is a relic of old conditions and poor regulation and with the use of the modern constant current transformer has been replaced largely by lamps of 3.5 w. p. c. efficiency.

As far as conditions of service are concerned with apparatus available which will insure uniform regulating conditions, and such apparatus *is* available, but one efficiency would seem necessary for series lamps. This class of central station service varies but little, as operating costs run about the same therefore, and the service is uniformly paid for on the basis of lamp year or lamp month. It, therefore, seemed that the new GEM filament lamp should be made and supplied in but one efficiency, namely, that efficiency which would give central station companies the minimum operating cost for this class of service covering cost of power delivered at the lamp and the cost of the lamp renewals.

Assuming the 25 c. p. lamp as a standard in the ranges of 5.5 ampere and below, there are in round figures practically three costs of lamp to consider, namely, 30c., 40c. and 50c.

Assuming further a cost per kilo-

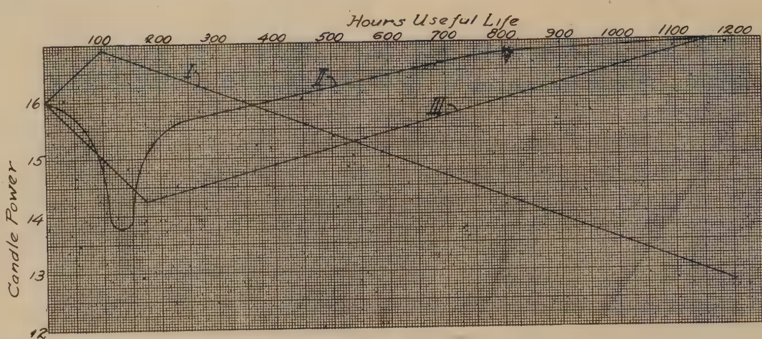


FIG. 2.

watt hour delivered at the lamp of 1c., 2c., 3c., and 4c. per K. W. hour, let us estimate the cost of light for an annual service of 4,000 hours for lamps of different efficiencies and plot the results as shown in the diagram, Fig. 3. The horizontal curves of this diagram represent the costs of lighting at different efficiencies covering lamp renewals and power at the rate shown. The three curves in each group arise from the three costs of lamps 30c., 40c. and 50c. for the different ampere ranges. You will notice that each of these curves has a minimum point, that is a point where the

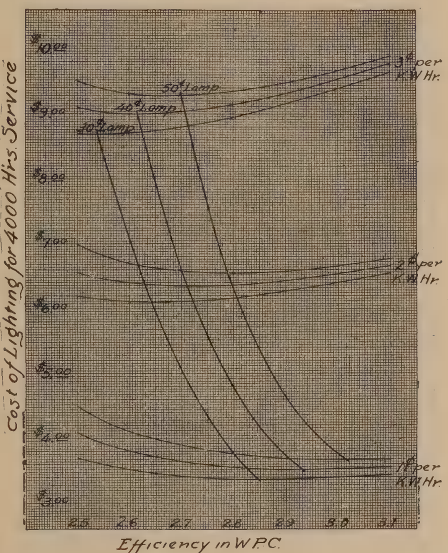


FIG. 3.

sum of the power and lamp renewals at varying efficiencies is a minimum. From these points are drawn the vertical lines shown which are lines indicating the efficiency for any given cost of power and cost of lamp that will secure the lowest cost of lighting service.

The writer understands that a safe figure for the cost of power delivered to lamp, for this class of service, including all charges, fixed and operating, is between 2 and 3 cents per K. W. hour. On this basis it is seen that the efficiency for the minimum cost, assuming an average price of 40 cents per lamp, is about 2.7 w. p. c. This efficiency has been accordingly adopted as the standard for the new GEM filament street series lamps with hopes that later higher efficiencies may be supplied.

The conditions of street series lighting service are different from those of the ordinary consumer's service and greater emphasis must be laid on the life of the lamp. Further, owing to the fact that light is sold by the lamp month or lamp year, the cost to central station is the correct basis for determining the efficiency of these lamps, and therefore materially longer life is required than in the regular lighting service with consumers. For this and other reasons it was decided to adopt the 2.7 w. p. c. efficiency for the new lamp although these new lamps could be supplied at 2.5 w. p. c. with a life equal to that of the present 3.5 w. p. c. At the efficiency adopted, 2.7, the life of the lamps will be about 50 per cent. longer than that of the present 3.5 w. p. c. lamps, and about an equal amount less than that of the present 4 w. p. c. lamps; that is, the life will be a mean of the present life values of the present 3.5 and 4 w. p. c. lamps of the same candle power and ampere range.

To determine the value of these new lamps in comparison with the present lamps, let us estimate the annual K. W. hour saving therewith.

Taking now the 25 c. p. lamps as a basis it gives a saving between the present and new lamp for the same life (1,000 hours) of 1 watt per candle or 25 watts. The actual hours of use for series lamps approximates 4,000 hours use per year giving us 100 K.W. hours saving per year per socket. 4,000 hours represents 4 lamp renewals per year so that the 100 K.W. hour total annual saving per socket is 25 K.W. hours saving per lamp. This is worth at 2c. total cost per K. W. hour 50c., or at 1c. total cost per K.W. hour 25c., which represents the additional value of the new GEM series lamp in this candle power. The increase in

price of the lamp for this c.p. is less than 10c.

In street lighting service central stations sell by the lamp year, so that the new series lamp would not reduce the income of the company (as it would where light is sold by meter on watt-hour basis). Central stations would therefore receive the full benefit of the saving of the new lamp.

Its effect on income would be something like the following:

Rates for street lighting are generally about $1.00 per c.p. per year. For 25-c.p. lamp is paid per year $24.00.

The income therefore for the same investment in station apparatus, 100 old lamps at $24.00	$2,400.00
140 new lamps at $24.00	3,360.00
Gain	960.00
Expense: Lamp renewals, old lamps at 39c. ea., 5 renewals per year	$195.00
Expense lamp renewals, new lamps at 7c. added price or 46c. each	322.00
Fixed charges in additional line equipment for 40 additional new lamps	30.00
Total	$352—$195=$157

Deducting this difference of $157 from the gain in income above, we find that the new lamp gives an additional net income of $803.00, or $8.03 per lamp per year.

With the introduction of new series lamp it is desirable for Central station companies to eliminate many of the present variations in ampere ranges and candle power sizes of lamps.

The following table shows the various types of street series lamps supplied and the watts and voltages per lamp for the two efficiencies of the present lamp and the new high efficiency filament lamp.

This table shows 7 ampere ranges and six candle-power sizes for each of 42 kinds of lamps—altogether too many varieties, many of which should be eliminated.

Choice of Ampere Ranges.

Choice of ampere range is determined largely by the number of lamps of any given candle-power it is desired to run on one circuit. The higher the amperage the lower the voltage of lamp and therefore the greater the number of lamps that can be operated on a given circuit. The following table shows this number for the different candle-powers and the ampere ranges for different primary voltages of 1,100, 2,200, etc., up to 5,500 volts. With the present constant current transformers it is practicable to employ voltages of 5,500 volts and average conditions will permit the use of at least 3,500 volts. It is desirable to keep the voltage above 3,000 to insure certainty of operation of the film cutouts in the lamp sockets.

The desirable number of lamps per circuit will vary according to conditions but appears to be from 100 to 150 lamps. On this basis I have drawn in on the table on page 201 (Table 2) a black line to separate the candle-powers which for any given primary voltage will run 100 lamps per circuit. Taking 3,500 volts as an average primary voltage, this permits of the use of the following candle-powers for the different ranges.

1.75	ampere	range	16 and 20 c.p.
3.0	"	"	20, 25 and 30 c.p.
3.5	"	"	20, 25, 30 and 40 c.p.
5.5	"	"	20, 25, 30, 40, 50 and 60 c.p.
6.6	"	"	20 to 75 c.p. inclusive.
7.5	"	"	30 to 75 c.p. "
9.6	"	"	30 to 100 c.p. "

By the use of 5,500 volts the range is extended to include 25 and 30 c.p. on 1.75 ampere range, and all the candle-powers in the other ranges.

Assuming 3,500 to 5,500 volts as the average circuit voltage, the above analysis shows us that it would not be necessary to employ higher amperages than 5.5 with 3,500 volts, or higher amperages than 3.5 or preferably 1.75 amperes with 5,500 volts to obtain 100 lamps per circuit. The use of lamps above 5.5 amperes seems to be confined largely to circuits in which the lamps used in series with arc lights. It is very desirable in point

Table I.

STREET SERIES LAMP DATA. VOLTS AND WATTS PER LAMP FOR VARIOUS EFFICIENCIES.

Ampere Range	Candle Power.	Present Series Lamps. 4 W. P. C. Efficiency. Volts.	Watts.	3.5 W. P. C. Efficiency. Volts.	Watts.	New GEM Filament Series Lamps. 2.7 W. P. C. Efficiency. Volts.	Watts.
1.75	16	36.6	64.0	32.0	56.0	24.70	43.2
	20	45.7	80.0	40.0	70.0	30.9	54.0
	25	57.2	100.0	50.0	87.5	38.60	67.5
	30	68.6	120.0	60.0	105.0	46.3	81.0
	40	91.4	160.0	80.0	140.0	61.70	108.0
	50	114.2	200.0	100.0	175.0	77.20	135.0
3.0	20	26.7	80.0	23.3	70.0	18.00	54.0
	25	33.3	100.0	29.2	87.5	22.5	67.5
	30	40.0	120.0	35.0	105.0	27.0	81.0
	40	53.3	160.0	46.7	140.0	36.0	108.0
	50	66.7	200.0	58.3	175.0	45.0	135.0
3.5	20	22.8	80.0	20.0	70.0	15.43	54.0
	25	28.6	100.0	25.0	87.5	19.30	67.5
	30	34.0	120.0	30.0	105.0	23.14	81.0
	40	45.7	160.0	40.0	140.0	30.85	108.0
	50	57.2	200.0	50.0	175.0	38.5	135.0
	65	74.3	260.0	65.0	227.5	50.0	175.5
5.5	20	14.55	80.0	12.72	70.0	9.818	54.0
	25	18.18	100.0	15.91	87.5	12.27	67.5
	30	21.8	120.0	19.09	105.0	14.727	81.0
	40	29.09	100.0	25.45	140.0	19.636	108.0
	50	36.36	200.0	31.81	175.0	24.545	135.0
	65	47.27	260.0	41.36	227.5	31.909	175.5
	75	54.54	300.0	47.72	262.5	36.818	202.5
	100	72.72	400.0	63.53	350.0	49.09	270.0
	125	90.91	500.0	79.5	437.5	61.36	337.5
6.6	20	11.72	80.0	10.6	70.0	8.18	54.0
	25	15.15	100.0	13.26	87.5	10.23	67.5
	30	18.18	120.0	15.91	105.0	12.27	81.0
	40	24.24	160.0	21.21	140.0	16.36	108.0
	50	30.30	200.0	26.52	175.0	20.45	135.0
	65	39.39	260.0	34.47	227.5	26.59	175.5
	75	45.45	300.0	39.77	262.5	30.68	202.5
	100	60.61	400.0	53.03	350.0	40.91	270.0
	125	75.76	500.0	66.29	437.5	51.14	337.5
7.5	30	16.0	120.0	14.0	105.0	10.80	81.0
	40	21.3	160.0	18.66	140.0	14.40	108.0
	50	26.66	200.0	23.33	175.0	18.0	135.0
	65	34.66	260.0	30.3	227.5	23.3	175.5
	75	40.0	300.0	35.0	262.5	27.0	202.5
	100	53.3	400.0	46.7	350.0	36.0	270.0
	125	66.66	500.0	57.7	432.5	45.0	337.5
9.6	30	12.5	120.0	10.9	105.0	8.43	81.0
	40	16.66	160.0	14.6	140.0	11.25	108.0
	50	20.85	200.0	18.2	175.0	14.1	135.0
	65	27.1	260.0	23.7	227.5	18.3	175.5
	75	31.3	300.0	27.3	262.5	21.1	202.5
	100	41.7	400.0	36.5	350.0	28.1	270.0
	125	52.1	500.0	46.0	437.5	35.1	337.5

of quality of lamps to keep the amperage of circuits as low as possible, as it is difficult to make series lamps of satisfactory quality of higher amperages where the volts per lamp is low and where the difficulties of exhaustion are therefore increased. The 5.5 ampere ranges of any candle-power give better life service than the 6.6 ampere lamps of the same candle-power. Likewise the 3.5 ampere lamps are better than the 5.5 ampere and the 1.75 ampere are better than the 3.5 ampere. Assuming candle-powers of 50 and less the best quality appears to be obtained in the ampere

ranges between one and three amperes.

It is to be sincerely hoped that the trend of practice will abandon the use of the higher ampere ranges such as 6½, 7½ and 9½ amperes.

Table 3 shows the Series Lamps demand (Ordinary Filament), classified by ampere ranges for the two efficiencies 3.5 and 4 w. p. c.

TABLE III.

PER CENT. CLASSIFICATION BY AMPERE RANGES (ALL C.P.'S.)

Amp.	3.1 w.p.c.	3.5 w.p.c.	4.0 w.p.c	Total All Eff.
1-2	0	7.7%	0.6%	4.5%
2.1-2.5	0	1.6	0	0.8
2.75-3.2	32.0%	6.8	0.7	7.3
3.25-3.8	0	24.7	5.0	15.7
4-5	0	2.42	1.6	1.9
5.2-5.8	65.8	42.2	13.8	35.3
6-7.8	0.1	13.2	74.2	31.1
7.9-10	3.04	1.5	4.2	3.4
				100%

DESIRABLE CANDLE POWERS

What determines the desirable candle-power for street lighting service? This considers not only the size of unit in c.p. but the distribution therefrom and this will be the subject of another paper. It appears to be also fixed, in a large measure by conditions of competition. Competition for this class of service is principally against the Welsbach gas lamps and it has been found by tests that the 30-c.p. street series incandescent lamp, will under ordinary conditions, give equivalent illumination to the ordinary Welsbach street lamp. In practice the majority of electric street series lamps are 25 c.p. which some companies claim is the equivalent of the Welsbach light. Other companies employ 40 c.p. and 50 c.p. in some cases in response to the demand for greater volume of light from public authorities. Lamps of the higher candle-powers 65 and 125 are apparently very little used and are required for use chiefly on arc lighting circuits in the high ampere ranges. The following table (Table 4) is interesting as showing the relative percentage demand for street series lamps in the various candle-powers for the two efficiencies. This table shows that 90 per cent. and over of the lamps are from 20 to 40 c.p. only with 57 per cent. in 20 and 25 c.p.

TABLE IV.

PER CENT. CLASSIFICATION OF DEMAND FOR ST. SERIES LAMPS BY CANDLE POWERS. (ALL RANGES OF AMPERES.)

C.P.	3.1 w.p.c.	3.5 w.p.c.	4.0 w.p.c.	Total All Eff.
20-25	22.2%	6.2%	57.5%	56.8%
30-40	77.7	35.0	31.5	37.6
50-65	0.1	3.0	9.0	4.9
75-125	0	0	2.0	0.7
	100%	100%	100%	100%

GENERAL CONCLUSIONS

Summing up the various points we find that desirable practice for street series lamps covers the use of 25 to 30-c.p. lamps in the ampere ranges of 3.5 and less, preferably 1.75 amperes, employing a primary voltage of 3,500 to 5,500 giving 100 or more lamps per circuit.

PRACTICAL ADVANTAGES OF INCANDESCENT LAMPS FOR STREET LIGHTING.

The best system of street lighting is clearly that which gives an even light of sufficient intensity over all parts of the street. All form of street lights give plenty of light near the lamps. The limiting feature seems to be the intensity of light half way between the lamps or at a considerable distance from the lamps where the light is weakest. If the light from the lamp be very strong, that at the half way point is rendered less effective by contrast. This, as we all remember, was the trouble with the old open arc lamp and the basis of improvement rendered by modern enclosed lamps and appurtenances. It is a well-known maxim that uniformity is the chief requisite of good illumination, and this is particularly true of street lighting where a very strong light placed at infrequent intervals may give a poor and unsatisfactory illumination due to lack of uniformity. This lack of uniformity results not only in waste of light over this strongly illuminated area but still greater waste throughout by the reduction of the sensitiveness of the eye for the light. In many cases, therefore, the total amount of light

given and cost of illumination may be reduced materially to the betterment of the illumination.

The series incandescent lamp hardly comes into competition with the arc light which is required for different conditions of service. The incandescent lamp, however, does come into competition with the Welsbach gas lamp which competition has occurred in localities where gas pipes and lamps are already installed.

The series incandescent lamp, however, with the improvements which are now available, should be able to effectually compete with the Welsbach

TABLE II.

TABLE SHOWING NUMBER OF NEW GEM SERIES LAMPS 2.7 W. P. C. THAT CAN BE OPERATED ON A CIRCUIT WITH VARIOUS LINE VOLTAGES.

Ampere Range.	C. P.	Volts.	Number of Lamps per Circuit for Primary Line Voltage of 1100 (1000)	2200 (2000)	3500 (3200)	4400 (4000)	5500 (5000)
1.75	16	24.70	40	81	129	162	200
	20	30.90	32	65	107	129	162
	25	38.60	26	52	83	103	129
	30	46.3	21	43	69	86	108
	40	61.70	16	32	52	65	81
	50	77.20	13	26	41	52	65
3.0	20	18.0	55	111	178	222	278
	25	22.5	44	89	142	178	222
	30	27.0	37	74	119	148	185
	40	36.0	28	55	89	111	139
	50	45.0	22	44	71	89	111
3.5	20	15.43	64	129	206	258	323
	25	19.30	52	103	166	207	259
	30	23.14	43	86	138	173	216
	40	30.85	32	65	104	130	216
	50	38.5	26	52	83	104	130
	65	50.0	20	40	64	80	100
5.5	20	9.818	102	204	326	407	510
	25	12.27	81	163	261	326	407
	30	14.727	68	135	217	271	339
	40	19.636	51	102	163	203	254
	50	24.545	40	81	130	163	204
	65	31.909	31	63	100	125	157
	75	36.818	27	54.3	87	108	135
	100	49.09	20	40	65	81	102
	125	61.36	16	32	52	65	81
6.6	20	8.18	122	244	391	488	610
	25	10.23	97	195	312	390	488
	30	12.27	81	163	261	326	408
	40	16.36	61	122	195	244	306
	50	20.45	49	98	156	195	244
	65	26.59	37	75	120	150	188
	75	30.68	32	65	104	130	163
	100	40.91	24	49	78	98	122
	125	51.14	19	39	62	78	98
7.5	30	10.80	92	185	296	370	463
	40	14.40	69	139	222	278	347
	50	18.0	55	111	177	222	278
	65	23.3	43	86	137	171	214
	75	27.0	37	74	118	148	185
	100	36.0	28	55	89	111	139
	125	45.0	22	44	71	89	111
9.6	30	8.43	119	237	356	474	594
	40	11.25	89	177	284	356	445
	50	14.1	71	142	227	284	355
	65	18.3	55	109	175	218	273
	75	21.1	47	95	152	189	236
	100	28.1	35	71	113	142	177
	125	35.1	28	57	91	114	143

light for street lighting service by reason of the following advantages:

1st. Ease of control from a distance permitting lighting and extinguishing lamps as conditions may require, and therefore the ability to take full advantage of a moonlight schedule as the weather permits.

2nd. Lamps are less effected by weather conditions than the Welsbach lamps. Incandescent lamps lend themselves to better and more accurate testing so that a more uniform product is insured. Also variation of pressure causing reduction of light is more readily detected and prevented with incandescent lights than with gas through the facility with which electric current can be measured. Electric lamps have also a materially better maintenance of candle power than Welsbach lamps.

3rd. The light of the incandescent lamp is yellow and more able to penetrate fog and smoke than gas lamps, and these are conditions where the light is especially desirable.

4th. Incandescent lamps can be installed along interurban roads and urban localities more readily and at less expense than a similar installation of gas lamps.

5th. Incandescent lamps operate so as to throw the light downward and therefore clearly illuminate the space beneath the lamp which is in shadow with gas lamps.

6th. The incandescent lamp has the advantage of being suspended over the street or roadway. The Welsbach light is placed on the sidewalk in most cases in line with trees which cast shadows and obstruct the light of the lamp. This last advantage always secures a better lighting effect from incandescent lamps on the houses and building on the opposite side of the road than where gas lamps are used.

This is well illustrated by the following photographs which are taken under exactly the same conditions.

On the basis of cost, assuming the 25-c.p. incandescent lamp as equivalent in illumination to the ordinary Welsbach we have the following comparisons.

Welsbach consumes 3½ cubic feet for one thousand hours would cost at $1.00 per thousand for gas $3.50. The 25-c.p. incandescent lamp of the new high efficiency type will consume for 1,000 hours 62.5 kilowatts which would give an equal cost with that of the gas at a rate of a little over 5½c. per k.w. hour.

On this class of lighting service with long hours of use and large number of lamps such a rate should be profitable one and even lower rates might be profitably made. In general, of course, the k.w. hour rate is not made, simply a rate per lamp per year including power and lamp renewals. This would amount in aforesaid rates to $15.00 per year for a 25-c.p. lamp.

The illumination from street series lamps could be materially improved by the introduction of a suitable and efficient form of reflector for use with the lamps. The form of reflector in general use now is the same that was used 10 or 15 years ago. It presents few points of advantage and could be materially improved upon.

The writer regrets that he has not had the time to go into the subject more thoroughly, but hopes the discussion will bring out interesting data relative to many important questions thereon, among others, the most desirable distance between lamps, the proper height and position of lamps, suitable type of reflectors for lamps, the desirable candle-power of lamps, etc.—in short the important questions of how best to obtain the most effective light distribution.

Papers Presented to Scientific Societies

HYGIENIC EFFECT OF LIGHTING BY GAS

By A. P. Beardsley, Ph.D.*
New England Ass'n of Gas Engineers, Boston.

In studying the effect upon health of the air of rooms in which gas is burned, it will be interesting first to give some attention to the matter of the changes of air in an ordinary room and the influence of gas lighting upon ventilation. This will bring up naturally to the more direct consideration of the composition of the air in gas lighted rooms and the effect of the products of combustion upon health.

It is surprising how often the air changes even in rooms where no special attention is paid to securing good ventilation. Fresh air passes in through the crevices of doors and windows in the lower half of the room, and out through similar openings in the upper half, as well as through fireplaces and chimney openings. Even the walls themselves help in the circulation. Experiment has shown that about 7 cubic ft. of air per hour pass in from outside through a square yard of wall when there is a difference of 40 deg. of temperature inside and outside. Prof. V. B. Lewes, of the Royal Naval College, Greenwich, England, found that in a room 10 ft. square and 10 ft. high, containing a small fireplace, but no fire, and one window and door, which were kept closed, the air changed nearly three times in the course of an hour.[1] This was by ventilation up the fireplace and through the walls and the crevices of window and door. Pettenkofer, a German chemist, found that in rooms of 1,400 cu. ft. capacity, with chimney openings, a quantity of air over three times the capacity of the rooms passed through every hour. With every visible chink and crevice except the chimney stopped, this quantity was diminished by only 28 per cent. He also found, in another investigation, that a good stove increased the quantity of air passing through the room by 50 per cent.

The value of a gas flame as an assistant in securing good ventilation is marked. The warmth of the air in the room produces a natural flow upward, and this current is much intensified by the powerful draft created by a gas burner. Even in a closed room a more rapid change of air results, for, as has been noticed, there is a very considerable passage of air through the crevices of such a room. If ventilating openings at the top of the room are provided, an increased circulation results—possibly too much in some weathers, on account of the loss of heat. In absence of special openings, however, much the same result may be obtained, and to any desired degree, by opening a window more or less at the top. In most houses, moreover, the living rooms communicate directly with a hall in which is a stairway, which constitutes a very effective ventilating shaft.

Bearing directly upon this subject are the results obtained by Dr. Percy Frankland in his analyses of the air in the Birmingham, England, Art Gallery.[2]. This gallery was lighted with incandescent gas lights, provided with ventilators overhead. It was feared by some that the use of gas might cause injury to the pictures, and that electric light should be substituted. Dr. Frankland was therefore called upon to test the air of the gallery:

a. When no lights were in use.

b. When electric arc lights were used.

c. When incandescent gas lights were in use.

The results he found were as follows:

a. In the absence of artificial illumination there was a slight increase in the amount of carbonic acid during the day.

b. When electric arc lamps were used, this increase was distinctly more marked.

c. When incandescent gas was used, the amount of carbonic acid was less than when there was no light at all. This showed very plainly the value of gas burners, when properly placed, as assistants in ventilation.

Before leaving this subject, it may be well to notice that the air from the breath rises naturally on account of its warmth. Gas burners are in almost all cases located above the level of the head. They therefore take the air after it has passed through the lungs, not before, and hurry it along directly and positively to the openings available.

Coming to the question of the effect of the combustion products of gas upon health, it has sometimes been claimed that acetylene and carbonic oxide were among these products. Experiments by careful investigators, however, have uniformly failed to show the presence of acetylene. In regard to carbonic oxide, some experimenters[3] have been unable to find any, while others[4] claim to have detected traces. The insignificant amount of the latter is shown by the following calculation: In a room 12 ft. wide, 16 ft. long and 10 ft. high, having three

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* New Haven, Conn.

[1] *Journal of Gas Lighting,* April 13, 1897, page 846.

[2] *Journal of Gas Lighting,* July 29, 1902, page 267.

[3] *Lancet,* Jan. 5, 1895; *Journal of Gas Lighting,* Nov. 19, 1895, page 1,024.

[4] *Journal of Gas Lighting,* Nov. 24, 1903, page 475.

[5] *Journal of Gas Lighting,* Oct. 16, 1900, page 948; also Report of Departmental Committee—Water Gas—English Government Blue Book, 1899.

changes of air per hour and lighted by a gas jet burning 6 cu. ft. per hour, the quantity of carbonic oxide which has been claimed would amount to about 1 part in 3,000,000. As the amount required to produce symptoms of poisoning, even after several hours' exposure, is 1,500 parts in 3,000,000, the matter cannot be considered of importance.[5]

Sulphur dioxide in almost infinitesimal quantities is also produced by a gas burner. During the last three months, New Haven gas has contained an average of 14 grains of sulphur per 100 cubic feet, the legal requirement for purity being 20 grains. If we suppose a room of the same size as before, ventilated and lighted in the same way, this quantity of sulphur dioxide would amount to a little over ¼ of 1 part per 1,000,000. Four parts per 1,000,000 is the least quantity that can be detected by taste or smell, and there is no evidence whatever that this amount is in any way injurious. Actual experiment[6] has confirmed the insignificance of the sulphur in the air of gas lighted rooms. Gas containing more than twice the sulphur of New Haven gas was burned in a room about 10 ft. square and 10 ft. high, care being taken to prevent natural ventilation as far as possible by puttying the cracks of doors and windows and varnishing the walls. The test was made in London, where the outside air contains vastly more sulphur than the air of our cities. Nevertheless, the maximum amount of sulphur dioxide obtained was about ½ of 1 part per 1,000,000.

A cubic foot of gas such as is supplied in New Haven requires for its combustion the oxygen contained in 6.02 cu. ft. of air, and forms in burning 0.82 cu. ft. of carbonic acid and 1.15 cu. ft. of water vapor. A flat flame gas burner consumes about 6 cu. ft. an hour. A Welsbach burner gives about three times the light with a consumption of 3.5 cu. ft. per hour, a little more than half that required for the flat flame. It is thus seen that flat flame burners produce $6 \times 0.82 = 4.92$ cu. ft. of carbonic acid per hour, and a Welsbach burner $3.5 \times 0.82 = 2.87$ cu. ft. per hour.

Regarding the amount of carbonic acid in the human breath, probably the most accurate figures are those obtained in the respiration calorimeter experiments which have been conducted at Middletown, Conn., by Prof. W. O. Atwater, assisted by Prof. Rosa and Prof. Benedict.[7] These men find that the amount of carbonic acid exhaled varies greatly, according to the amount of work a man is doing. A man sleeping produces about 0.48 cu. ft. per hour, one exercising moderately about 1.9 cu. ft., and one performing very severe exercise about 4 cu. ft. In the ordinary living room a man seated will exhale about 0.76 cu. ft. of carbonic acid per hour. In addition, organic matter of bad odor is also evolved both by the lungs and skin.

In estimating the amount of carbonic acid ordinarily present in a living room, let us again suppose a room 12 ft. wide, 16 ft. long and 10 ft. high, in which three people are sitting. The room is lighted by a Welsbach burner overhead, which will give as much light as three ordinary burners or three and one-half 16-candle electric bulbs. It has been said before that with a room shut, as far as doors and windows are concerned, but with a fireplace, the air changes about three times per hour. It may be mentioned in passing that these experiments were conducted abroad, where the fireplaces are not nearly as large as our own. With doors open to the hall, or with the window slightly open at the top, the gas would certainly produce a better ventilation than three changes per hour. However, let us calculate on this latter figure. The air in this room would then contain 11.95 parts of carbon dioxide in 10,000, of which 3 would be that always present in fresh air, 5 that produced by the gas, and 39.5 that produced by the people. Just here a word in anticipation. While the carbonic acid produced by gas is the same substance as that produced by persons, the indication it affords of the fitness of the air for breathing is not at all the same. This point will be explained later. Prof. R. C. Carpenter, of Cornell, gives 8 parts of carbonic acid in 10.000 as a standard of good ventilation, but this figure, as will be understood later, is to be referred to the carbonic acid produced by people plus that always present in fresh air. In the above case the sum of these two is 6.95.

An actual test along this line has been made by the same Prof. Lewes before mentioned. He experimented with a sitting room 12 ft. long, 16 ft. wide and 12 ft. high. The room has a door and a window, which were kept closed, and a fireplace. It was lighted by three 7-ft. flat flame burners, and occupied by two people. The air in this room, closed tightly, as said, changed 14 times in five hours, and at the end of that period Prof. Lewes found only 21 parts of carbonic acid in 10,000. As stated, three large burners were used in this case.

It is to be noted that the carbonic acid produced by burning gas is accompanied only by water vapor and some insignificant amounts of sulphur compounds. The carbonic acid from human beings, however, is accompanied both by water vapor and organic impurities from the lungs and skin. This is an important fact, because, startling as it may sound, carbonic acid itself has no poisonous or injurious effect on the system. Regulations as to the amount of carbonic acid permissible in the air of a room are made because it is found that the

[6] *Journal of Gas Lighting*, Sept. 6, 1904, page 672.

[7] Year Book of U. S. Dept. of Agriculture, 1904.

organic impurities and the carbonic acid given off from the body bear a regular proportion to each other. It is difficult to directly determine the amount of organic impurities present, but if the amount of carbonic acid is learned, the organic impurities are known by inference. The statement that carbonic acid itself is not at all harmful is, of course, contrary to the older belief, but it is the conclusion of the best investigations. Among these may be mentioned the researches of Pettenkofer; the report[8] of Drs. J. S. Billings, S. Weir Mitchell and D. H. Bergey to the Smithsonian Institute; the report[9] of the British Departmental Committee to consider the ventilation of factories, and last and most important, the results of the experiments with the respiration calorimeter at Middletown, Conn.[10]

The men who are the subjects of these latter experiments live uninterruptedly for days in an atmosphere containing never less than 27 parts of carbonic acid in 10,000, or 9 times the amount in fresh air, and usually much more; sometimes as much as 225 parts per 10,000, or 75 times normal. In not one case has any ill effect been observed, either during the experiment or at any time afterward, nor have numerous blood counts shown any anæmic tendency. The men fail in regular health and are perfectly unaware from any sensation of the great amount of carbonic acid present. It should be mentioned, however, that the air is dried before being supplied to the men. Professor Benedict, who conducts the experiments, told the writer that it was impossible, even under the worst conditions of ventilation, to produce in a room an amount of carbonic acid which in itself would have an ill effect.

It appears, then, that we may not attribute a sensation of close or bad air in a room to an excess of carbonic acid. Authorities tell us also that any ordinary diminution of the per cent. of oxygen present cannot account for it.[11]. The cause seems to be something quite different. Professor Benedict, in common with other investigators, lays it to three factors. The first, though not the most important, is unpleasant odors. The effect of these is mental rather than physical, but very real, nevertheless. But the two most important causes of closeness are high temperature and excessive moisture, particularly the latter. Temperature and moisture are related to each other in the fact that with a high temperature more moisture is allowable and necessary than with a low temperature. A certain balance between the two, or a per cent. of saturation, is necessary for health and comfort. The removal of moisture from the body by insensible perspiration and by the breath will be unduly hastened or hindered, as the case may be, according as there is a lack or an excess of moisture in the air. An excess of moisture, however, appears to be most often responsible for discomfort.

Since water vapor is one the products of the combustion of gas, we are at once met by the question: What is the effect of gas lights upon the moisture in a room? A certain amount of water vapor, as said, is necessary for health and comfort. Authorities say about 50 per cent. of that required to produce saturation of the air is the proper amount. It is only in the summer time that the air of our houses, as drawn in from outside, contains that amount. As soon as fall comes and the furnaces are started, the usual complaint is of the dryness of our rooms, and water is often purposely evaporated to supply the lack. It is only in the summer, therefore, that the moisture from the gas flame would be undesirable, and in the summer time our houses are as open as it is possible to make them. With air pouring in through every door and window, the moisture added to the air by a gas flame is indistinguishable. During the rest of the year the addition of moisture by gas is not only not an annoyance, but a benefit.

In conclusion, it may be said that it is anything but the object of this paper to undervalue the importance of good ventilation. That is a matter of which experience has shown the necessity, irrespective of the question of lighting. It does appear, however, that efforts to show the poisonous character of the products of the combustion of gas lack corroboration by the best scientific investigations, and it is in the effort to present a few of these facts that this paper has been undertaken.

[8] Smithsonian Contributions to Knowledge, Vol. 29.

[9] Government Blue Book, 1902; also *Journal of Gas Lighting*, Nov. 25, 1902, page 1,398.

[10] Year Book of the U. S. Dept. of Agriculture for 1904.

[11] Smithsonian Contributions to Knowledge, Vol. 29.

WORK WITH ILLUMINATION AND STREET PHOTOMETERS*

W. E. CATON.

The question of the candle-power of various lamps and burners is one which daily comes into greater prominence. The author, therefore, thinks that gas engineers should do more in the way of testing lamps and burners in position where they are fixed. The subject the writer has chosen will bring before your notice two photometers—an illuminating power photometer and a street photometer—both of which are designed for this purpose, and which he has used with considerable advantage.

* Paper read before the Midland Junior Gas Engineering Association, England.

THE ILLUMINATING POWER PHOTOMETER.

The illuminating power photometer differs from most photometers in this respect, that the readings are recorded in parts of a candle-foot. [A candle-foot, of course, being the amount of light given by a standard sperm candle at a foot distance.] The use of this photometer has been very exhaustively dealt with by Mr. Henry Fowler, the Gas Engineer to the Midland Railway Company, in a paper read by him before the Manchester District Institution of Gas Engineers on March 7, 1904, but presented for the previous December meeting. For the benefit of those who have not perused this communication, I will read some of his remarks as an introduction to my paper.

The theoretical calculation of the amount of illumination on any plane may be easily arrived at if the whole of the light is concentrated at one point by the following method: In Fig. 1, let A be the source of light, having an intensity in every direction of x candles, and B a point directly below it. We know that the illumination at B is equal to x divided by $A\,B^2$ (A B being in feet) and is therefore $\frac{x}{A\,B^2}$ of a candle foot. At C, on a plane at right angles to A C, the illumination is $\frac{x}{A\,C^2}$; but on a plane at right angles to A B is $\frac{x}{A\,C^2}$ multiplied by the cosine of the angle of incidence B A C, and therefore is equal to

$$\frac{x}{A\,C^2}\ \mathrm{Cos.}\ B\,A\,C = \frac{x \times A\,B}{A\,C^2 \times A\,C} = \frac{x \times A\,B}{A\,C^3}$$

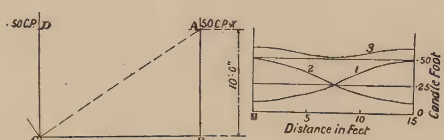


Fig. 1 Fig. 2.

This is simply the candle-power multiplied by the cosine of the angle of incidence and divided by the square of the slant distance. A curve (1) of the illumination along B C is shown under Fig. 2 as a full line, in which x is assumed to be 50 candles and A B to be 10 feet. This is, of course, the curve for a single light. If other lights have to be considered, the illumination along C B is the sum of the respective illuminations given by them. Assuming another light to be at D (Fig. 1), A D being equal to one and a-half times A B, the illumination from these two lights will be the sum of the curves 1 and 2, as shown by curve 3 (Fig. 2). It will be seen that the actual amount of illumination on a given spot—such, for instance, as on any floor of a room, on a desk or table, etc.—can be theoretically calculated.

Various forms of illumination photometers have been devised; but the one the author has been using—the Preece-Trotter photometer—is the most reliable. Fig. 3 shows a section through this type of photometer, which consists of a body A, of 3-inch diameter tube, attached to a stand B, which may be placed directly on the floor or on a tripod as required. C is an amyl-acetate lamp screwed into a casing D from beneath, which allows the flame to be adjusted to a standard height, which is indicated by means of the gauge T. The ends G G of the photometer are secured by means of bayonet joints. Near the lamp is provided a mirror, to allow of the flame being inspected without taking the end off. The inclined Bristol board H is directly pivoted to the lever I, the end of which works on the quadrant marked with the reading in parts of a candle foot. The disc J is held down by a circular rim, and has in it a slot lying at right angles to the axis of the barrel. K K are metal screens with pear-shaped holes in them, which prevent, to some extent, the stray reflections which take place in the interior of a box however carefully it may have been blackened. The scale is marked for readings from 0 to 2.2 of a candle foot; the amyl-acetate lamp giving on the bar a reading of 0.25 candle.

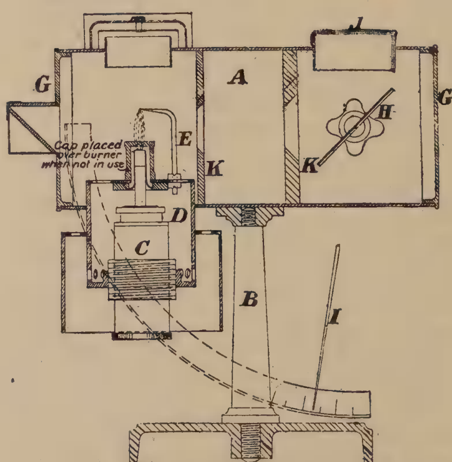


Fig. 3

To take a reading, it is necessary to move the lever backwards and forwards, exposing the Bristol board to the standard light at different angles, which is seen through the slot in the circular cardboard disc. The illumination on the Bristol board increases as the same approaches the vertical, and vice-versa. The rays of light from the lamp under test shine on to the circular cardboard disc; and by moving the lever, as previously stated, until the same density of light is obtained on the disc and through

the slot, the reading on the quadrant scale can then be observed. It will, therefore, be seen that this is practically a "Flicker" photometer. With this photometer, one is able to actually read the illumination on a given spot in parts of a candle-foot which has been theoretically calculated.

From any reading thus taken the actual candle-power of the lamp can be calculated by the aid of the formula given. It will be found that the candle-power varies considerably with the angle at which it is taken. Take, for instance, an ordinary incandescent burner, ten feet high. The theoretical illumination is greatest directly underneath. But in practice the highest illumination will be found at a short distance away, owing to the shadow cast by the burner; and the further you get away, the candle-power will slightly increase, owing to the burner not cutting off from view so great a portion of the mantle. This is overcome by the inverted incandescent gas burners. With this type of photometer curves of illumination can be taken longitudinally and crossway of a room, shop or large building, for comparison (say) with another room lighted in a different way.

Some of the disadvantages of this type of photometer—which is, the author believes, the only one of its kind in use—are that no readings can be taken directly under a light; while the amyl-acetate lamp, giving a reddish colored light, requires a considerable amount of practice to read accurately when testing electric arcs or incandescent gas lights, also, owing to draughts affecting the standard flame, it can only be used outside on a still, fine night. The author thinks if some similar photometer was designed at the present time which would do away with the color difficulty, and in which a higher standard was used, a demand for it would soon spring up, as he feels sure something after this kind would be found very useful to the engineer in these days of keen competition with the electric light.

The street photometer which the author has used is the Simmance-Abady. Fig. 4 shows a form of this type of photometer, which consists of a box about 2 ft. 8 in. long by 11 in. wide by 1 ft. 6 in. high. Inside this box a small tank A, containing pentane, is fixed, which supplies the burner B with pentane vapor by means of rubber tubing. This burner, when adjusted to the proper height, gives a light equal to one standard sperm candle, and is capable of being moved from end to end of the box by means of a cord actuated by a screw C. On the front of the box is a blue glass scale, marked in inches and tenths of an inch from the center of the "Flicker" head. Outside the box is fixed one of Simmance & Abady's "Flicker" photometers, by means of which lights of blue, green, red or any other color can be tested with accuracy. The whole is mounted on a carriage and is capable of being wheeled from place to place.

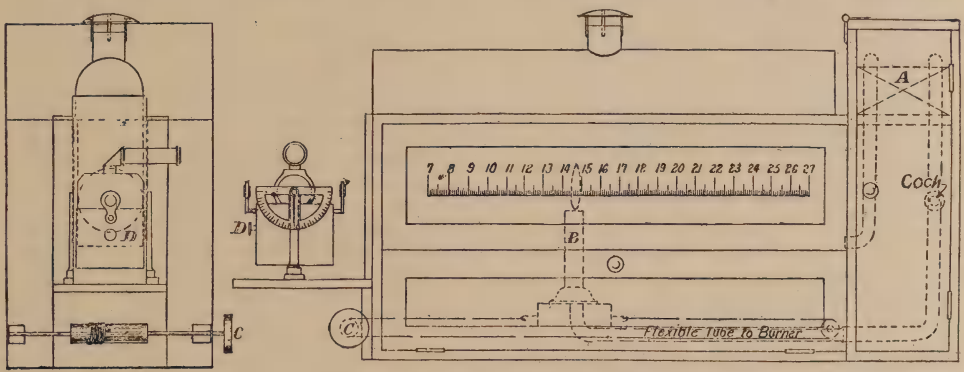


Fig. 4

To make a test of a lamp it is necessary, after having decided on the horizontal distance away from the lamp, to find the angle of elevation of the lamp, then bisect this angle and fix the "Flicker" head to this bisected angle, as shown on the divided scale. Start the "Flicker" going by turning the screw D, and move the standard burner, by the aid of the screw C, to a position where the flickering disappears. Take notice of this position as indicated by the pointer on the blue glass scale. The horizontal distance between the flicker head and the center line of the lamp being accurately measured and the angle of elevation taken, it is easy to find the distance from the flicker head to the center of the light. The distance, expressed in inches squared, divided by the square of the distance as noted on the blue glass scale, gives the candle-power of the lamp. This photometer cannot be used to test the illumination on a given plane, as can the Preece-Trotter illumination photometer, but only records the actual candle-power of the lamp under test.

GENERATION AND USE OF ACETYLENE

By Sir Charles S. Forbes.

(Abstract of paper presented before the Association of Engineers-in-Charge, England.)

After referring to the furnaces used for the manufacture of the carbide, he passed on to the generation of acetylene gas; remarking that the action of water upon carbide was extremely rapid, and gave rise, unless in some way controlled, to a great deal of heat. Properly designed acetylene generators must therefore be so constructed as to get rid of the heat as formed, in order not to allow the temperature of the gas to become excessively high. If this were not done, the gas was split up into other compounds. The regulations of the Acetylene Association were to the effect that the gas, before leaving the generator, must not be of a higher temperature than the boiling-point of water; and the Home Office insisted that it must not be stored at a higher pressure than that of a column of water 20 inches high. The author then described the various types of generators, which he classified for this purpose as follows: (1) Automatic generators with carbide in excess; (2) automatic generators with water in excess, where the water is made to rise up under and attack the carbide; (3) non-automatic generators with water in excess, where the water is made to rise up and attack the carbide; (4) non-automatic carbide-to-water generators, with water in excess; and (5) automatic carbide-to-water generators, with water in excess. Allusion was also made to the Atkins dry process, in which, instead of employing water for the generation of the gas, use is made of powdered washing soda, which is mixed with granulated carbide in an apparatus closely resembling a barrel-churn, the handle of which is turned round and the gas gradually generated and stored for use in the holder. In this case, it was claimed that a bye-product was produced which was valuable and saleable; but he (Sir Charles) had not had an opportunity of verifying or checking the statement. No systematic method had yet been adopted for the disposal of residues from acetylene generators; but when this was done (as no doubt it would be some day) the cost of the gas would, of course, be less.

Passing to the question of pipes and fittings, the author said, as the amount of gas used in an acetylene burner was less in proportion to the light given than in the case of other gas, it would appear, at first sight, as if much smaller pipes were necessary. It was a mistake, however, to run the main pipes in a building too small, though the service-pipes to the burners themselves could, if required, be left as small as ⅛ inch for a short distance. In no case should anything but iron pipes be used in the house—except, of course, where brass was employed for the sake of appearance. Compo. pipe was not to be recommended, owing to its liability to mechanical damage. In the fittings, great care should be taken to see that the cocks and joints were all well ground in, and had plenty of bearing surface; any bad work would result in annoyance. Special attention was drawn to the acetylene burner introduced by Messrs. Geo. Bray and Co., which allows of the flame being turned down without any choking from carbon resulting. Touching upon incandescent acetylene lighting, Sir Charles said that, so far as his short experience went, he could not get the mantles to last more than a few days, as when lighting the gas they were apt to break. At present he was afraid that acetylene could not compare favorably in cost for cooking purposes with gas or oil; but it was, of course, much cheaper for this purpose than electricity. There had, however, lately been a very important development in the use of acetylene for welding, owing to the introduction of an oxygen blow-pipe invented by M. Fouché, of Paris. The results obtainable in welding iron and steel with this process were, he said, nothing short of marvelous. Acetylene could, he concluded, easily be employed for driving gas-engines. Acetylene for power purposes was, however, as at present used, distinctly expensive; and for this reason, he would advocate the adoption of electric ignition instead of the tube, since, so far as he could see, the bunsen burner for the tube would consume as much gas as would drive a fair-sized engine.

The paper was followed by a brief discussion, in the course of which Mr. F. S. Thorn referred to the question of the use of incandescent mantles with acetylene. He said that with the bursting of a mantle the expense of a new one was not the only trouble; another result was that everything in the room was in a very few moments covered with lampblack or soot in its worst form. Another speaker, Mr. Horace Allen, said that in using acetylene the first difficulty met with was in opening the receptacle containing the calcium carbide. This could not be done near an inhabited room. Then, again, there was the trouble of getting rid of the refuse. Sir Charles Forbes, in replying to points that had been raised, said his reason for claiming that acetylene was a better light than electricity, was that his lady friends said they could not see properly with electricity, and that they could with acetylene. The incandescent electric lamp was very trying to the eyes unless the right pressure was on; but if the correct pressure could be always maintained, it was, of course, extremely good and convenient.

Review of the Technical Press

AMERICAN ITEMS

THE DISTRIBUTION OF ILLUMINATION IN THE NEIGHBORHOOD OF TWO LAMPS.—J. R. Benton. *Electrical World,* May 5, 1906.

The general object of the paper is indicated in the opening paragraph:

"The distribution of illumination in the neighborhood of a single source of light follows a very simple law, being inversely proportional to the square of the distance from the source; but when illumination takes place from several sources its distribution becomes far more complicated, and cannot generally be computed in advance. In practice, illumination is very frequently effected by using several sources, as when lamps are placed at intervals near the ceiling of a room. It would be advantageous if the illumination to be obtained at any point by such an arrangement could be computed in advance, since the information gained by a mathematical study of the condition would be helpful in deciding upon the best number, spacing and power for the lamps to be used."

Mr. Benton discusses the following three propositions:

"(1) When the positions of the two sources and their candle-powers have been fixed upon, to find the resulting intensity of illumination at any point;

(2) When the positions, but not the powers, of the two sources have been fixed upon, to decide what is the proper candle-power for each in order to produce a given illumination at given points;

(3) When the positions of the sources have not been fixed upon, to ascertain how they should be placed in order to get the best distribution of light in a room of any given shape and size."

Assuming the light-sources to be points, and hence distributing their light uniformly in every direction, the writer proceeds to set forth a mathematical solution of such a proposition. Since commercial light-sources are never points, and therefore never distribute their light anywhere near equally in all directions, the formulæ and tables given would seem to be of little use to the illuminating engineer. To consider a chandelier a point is certainly a discrepancy too wide even for the admittedly rather loose calculations which must usually serve in illuminating engineering problems. Furthermore, if a chandelier as a whole be considered as single light-source, the number of light-sources which need be taken into calculations in determining the illumination upon any given surface is not so large as to render the problem "impractically laborious." The practical problem that confronts the illuminating engineer in predetermining the location and character of the light-source is the manner in which the units, whether single light-sources, or a collection supported by a single fixture, distribute their light in a vertical plane, and his skill will be best applied in determining what form of reflector or accessory will be required to so distribute the light when the fixtures are placed in some acceptable position so as to give as nearly as possible the theoretical illumination required on some basis assumed as a standard. To evolve long formulae on the theory of point source is simply "loves labor lost," so far as illuminating engineering is concerned.

THE LIGHTING OF DESKS. J. R. Cravath and V. R. Lansingh. *Electrical World,* May 5, 1906.

An article on this practical and important subject illustrated with nine half-tone cuts. The writers set down the following rules for proper desk lighting:

"1. The light should be out of the line of ordinary vision of the person working at the desk or should be shaded so that the rays cannot strike the eye.

2. The position of the lamp with reference to the top of the desk should be such that the worker at the desk will not receive the regular reflection or glare from paper on the desk. This regular reflection is one of the commonest causes of trouble in continued working at an artificially lighted desk.

3. The light should be free from streaks or striations.

4. Too great intensity of light should be avoided. An intensity of from 3 to 5 candle-feet (normal) on the top of the desk is about right.

5. The light should be steady—in other words, should not be swinging; and if it is electric light the voltage regulation must be good."

In giving 3 to 5 foot-candles as the requisite illumination we believe they have overstepped the mark, as the important objects which are viewed at a desk are white, and an illumination of 5 foot-candles intensity would seem to be unnecessarily brilliant.

The writers call attention to the fact that their illustrations are not taken by artificial light produced for the desk, but by daylight, stating that "as a matter of fact, it would be impossible, as any photographer knows, to take such photographs by artificial light."

The authors show an arrangement which they state is "one of the most satisfactory, comfortable and efficient ways of desk lighting." The lamp is located on a bracket at the left hand of the desk. The bracket is equipped with a concentrating type of prismatic glass reflector. Again we must dissent from their opinion. The lamp is placed sufficiently high to shine directly into the eyes. The fact that it is above the line of vision, that is, above the height of the eyes of the person sitting at the desk, does not by any means remove the objection which they set down as the first requirement. In fact a lamp above the line of vision and still in such position as to shine into the eye, produces one of the worst possible effects. The light reaches the eye from such a source at an unusual angle and is extremely fatiguing.

The illustration given below (Fig. 1) is from a photograph taken entirely by artificial light, which is a perfectly simple matter, and also by the single desk light as shown. The fact that the lamp and reflector are lost in the photo is a clear indication that the effect on the eyes would be glaring and unpleasant.

Their views of the proper positions for standard portable desk lights are open to the same criticism.

In only one of the illustrations can we agree with the writers as to good desk lighting, and that is the lamp on the flat top desk. In this case the lamp is brought forward to the extreme left hand corner of the desk and the reflector shade so

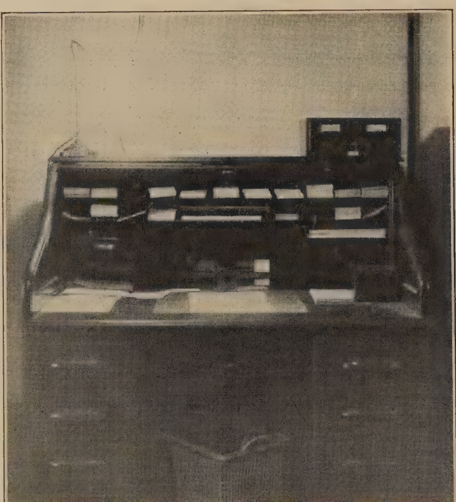


FIG. 1.

turned as to throw the light upon the paper while entirely hiding the lamp from view.

Fig. 2 shows an arrangement for a desk light that is free from all the objections we have made. The small reflector at the left entirely hides the lamp, while giving a strong light at the proper angle. The lamp and reflector are turned back when the desk is closed.

FIG. 2.

ARTIFICIAL ILLUMINATION.—Dr. Edwin James Houston. *Electrical Age*, April, being the eleventh article in the series.

In this article the author discusses "that type of artificial illumination which requires the use of a light of marked brilliancy, with color values closely approaching those of ordinary sunlight. In all the cases which come under this head, i. e., ball-rooms, theatres, the lobbies, grand staircases, and dining rooms of large hotels, bowling alleys, billiard rooms and barber shops, the entire space requires a brilliant and uniform illumination."

The article deals in the same general manner with these problems as with the problems dealt with in the preceeding numbers of the series. A series of illustrations are given, in a number of which care is taken to specify the particular make of incandescent lamp which is used in the installation.

We fear that the ladies will take exception to Dr. Houston's statement that "the illumination should have color values closely approaching those of ordinary sunlight in the illumination of ball rooms." It is an open secret with this important *clientelle,* that the mellowness of gas light hides a multitude of bad complexions, and a light of sunlight color value would be considered vulgar and glaring. Electric arc lamps, which are even more searching than daylight, may be turned upon the stage, where grease paint constitues the complexions of those exposed to its rays, but what manager would have the hardihood to throw a light of this quality upon the audience?

The writer further states that "either arc or incandescent lamps are suitable for the illumination of a ball room. If the arc lamps only are employed, they should be of the inclosed type and preferably be provided with translucent or strongly frosted globes. A combination of arc and incandescent lamps, however, produces a more pleasing effect than arc lamps alone, while, perhaps, the most pleasing effects possible are obtained by the suitable distribution of incandescent lamps of such high efficiency as to insure a close approach in their color values to those of daylight."

Enclosed lamps would undoubtedly "fill the bill" so far as furnishing light is concerned, especially since the "work done in a ball room is not of such a character as to require the most distinct vision." The quality of the light might depend upon the quality of the ball room. We can conceive of ball rooms where arc lamps would be admissible, but they are not the kind that good illuminating engineers are in the habit of frequenting. As to a combination of arc and incandescent lamps: that is an abuse of good illuminants which can scarcely be condoned on any conditions whatever.

The writer speaks several times of "the brilliancy that is not only permissible but desirable in such cases," but does not give any figures as to the requisite intensity in foot-candles.

There is some discussion of fixtures and accessories, and stress is laid upon the necessity of keeping lights out of the direct range of vision. The latter half of the article is taken up with discussion of special illumination in factories, mills, workshops, etc., and also the projection of light by lenses and reflectors. The directions given are such as are generally familiar to the layman.

Twenty-five Cycle Lighting.—Chas. F. Scott. *The Electric Journal*, April, 1906.

After discussing briefly the physical and electrical action of such a current upon the ordinary incandescent lamp, the writer states:

"The eye is apparently more sensitive to the rapid variations in illumination when the light is reflected from a surface, such as a white wall, than it is when it comes directly from the filament of the lamp. Different portions of the retina are not equally sensitive, light impinging upon the eye at an angle of about 45 degrees seems to strike a more sensitive region than light which comes from directly in front of the eye.

"In considering the effect upon the eye it is necessary to consider not only those vibrations which may be readily observed or detected when they are looked for, but also to note whether the fluctuations produce fatigue or nervousness, as the result of continuous use of the light in office work, although there may be no apparent immediate inconvenience. I recall that the eminent physicist, the late Professor Rowland, remarked that the proper test for the operation of incandescent lamps on low frequency alternating current would be to have an old lady use the light for reading and see whether it hurt her eyes. On second thought, this suggestion that the problem is really a physiological one does not seem to be far wrong.

"The problem is certainly a very interesting one from the theoretical standpoint. The real test, however, is the practical one of actual experience. Twenty-five cycle current is in pretty general use for incandescent lighting. The report in this issue of the illumination of the City of Buffalo is quite to the point. My own view of the matter is to the effect that the illumination by incandescent lamps at 25 cycles is, in general, quite satisfactory for most purposes, but it is impossible to give a broad assurance that it will always be found satisfactory for the reason that differences in the character of the current supplied and of the lamps used are important factors, and, moreover, lamps that would be satisfactory under most surroundings and for many kinds of service might be unsatisfactory in other surroundings when the requirements were quite exacting.

Lighting on 25 Cycles in Buffalo.—H. B. Alverson. *The Electric Journal*, April, 1906.

The writer, who is superintendent of the Cataract Power and Conduit Company, Buffalo, N. Y., states that incandescent lamps form the bulk of the lighting of this kind.

Discussing the flickering caused by frequencies of 25 cycles he comes to the conclusion that it is not sufficient to be objectionable. He states that lamps worked under the normal voltage show such flickering, but that the illumination under such conditions would be poor at any higher frequency. Arc lamps on this frequency have not been a success, nor have the Nernst lamps.

"Summing up: Twenty-five cycle illumination in Buffalo has proven equal in value to any other form of electric illumination save that of its use for arc lights, and in the latter case the difficulty has been easily met."

As to flickering of incandescent lamps on such a current, we have a very distinct recollection of our experience at the Pan American Exposition where the flickering due to this cause was not only very apparent, but decidedly annoying, and this with the best quality lamps that could be obtained running at their proper voltage.

ARC LIGHTING

By R. H. Henderson,

(*The Electric Journal,* April.)

Although there are tens of thousands of enclosed arc lamps installed in all parts of the country, very little in proportion to their use has been written concerning their design, operation and maintenance. Being adapted to almost every kind of commercial circuit, their importance in the equipment of a modern central station cannot be overestimated. Broadly speaking, there are certain fundamental elements of arc lamp design which must be found in all lamps, no matter whether for alternating or direct current, multiple or series.

DETAILS OF ARC INCLOSURE.

Primarily too much attention cannot be paid to the details of the arc enclosure. The gas check, or bulb cap, as it is sometimes called, must have the surface against which the inner globe rests, machined true and smooth in order to make the joint as nearly air tight as possible. This is of the greatest importance, and in the case of lamps for high tension this gas check should preferably be made of some heat resisting material with high insulating qualities, with a surface for the inner globe seat which will not corrode nor deteriorate. The finer grade of soapstone has been very successfully used for this purpose. Furthermore, in operating lamps the greatest care should be exercised in trimming to see that the inner globe rests uniformly and evenly on the finished surface of the gas check with a moderate pressure. If this pressure is too great it will result in the cracking or chipping of the inner globe, generally at the point of contact. Aside from the destruction of the inner globe the life of the carbons will be shortened directly in proportion to the amount of air admitted to the globe through the fracture. The extreme condition would be in the case of an inner globe being broken entirely so as to form no enclosure for the arc on a lamp which was not fitted with an outer globe. In this case, the life of the carbon, burning freely in the air, would be between six and seven hours, while the same carbon burning in a proper enclosure would last probably from 100 to 150 hours. So it is evident that there is no economy in using chipped or cracked inner globes, owing to the greatly decreased carbon life and the attendant disadvantage and expense of having to trim certain lamps on a circuit before the carbons in the others are burned out. Oftentimes, there is also an outage charge for such lamps which is deducted by the city or town, from the earnings of the central station. Outer globes should be kept up on street systems for the same reason, as their purpose is to protect the intensely heated surface of the inner globes against rain and snow.

BUSHINGS FOR THE CARBONS.

Aside from the seat for the inner globe the most important feature of a gas check is the center, or bushing, through which the carbon passes. This center must be designed with two different and distinct ends in view, one is to provide a smooth accurately fitted bushing through which the carbons must pass freely, the clearance, however, must not be greater than a few thousandths of an inch, for if it is more the life of the carbons will be materially reduced. The second requirement, often made of this bushing, is that it should act as a relief valve for the explosion of gases in the inner globe. This explosion is quite severe and takes place generally when a lamp is turned on after being out from seven to ten minutes, due to an explosive mixture of gases which forms in the inner globe. This mixture is ignited by the arc when the lamp is again switched on. To meet this requirement these bushings are arranged so as to have a slight vertical movement, allowing them to be lifted by the gases in such a manner as to open ports for equalizing the pressure with the atmosphere, thus tending to neutralize the effect of the explosion and the accompanying breakage of inner globes. The best practice in meeting these conditions seems to consist in making the gas check-plate of metal with an insulated center bushing for low tension lamps, and the reverse in high tension lamps.

The question of open and closed bottom inner globes has been debated for some time, but the best practice indicates that the closed bottom inner will soon be the standard. The closed bottom globe certainly possesses the obvious advantage of having only the one aperture to keep tightly closed in operation, while the open bottom has two, with twice the chance for air leakage. Perhaps every metal and alloy which is available for ordinary manufacturing purposes has been used for carbon holders in inner bulbs, but practice has demonstrated that iron, both cast and wrought, is the only metal which will successfully withstand the heat of the arc and not be deposited on the inside of the globe either in the form of dust or a brownish scale, which unites with the glass and cannot easily be removed. It is necessary, however, to make the carbon bushing of some metal which will not oxidize as easily as iron. On account of the small clearance between it and the carbon, brass is entirely suitable for this purpose, as the bushing is not really inside of the inner globe.

CLUTCHES.

Almost as important as the proper enclosure and combustion conditions in the arc, is the question of the clutch. Probably

more different forms of clutches have been made than any other part of the mechanism, yet viewed by present day standards, it is the simplest thing in the lamp. A clutch cannot be made of metal unless it is well insulated, which is quite a difficult matter. If it is not insulated, and the upper carbon is not firmly seated in its holder, the clutch will attempt to carry current to the carbon, with the invariable result that the clutch is injured by having its edges fused at the point of contact with the carbon. Again, a clutch with many pieces is all the more liable to get out of order, so the simplest possible clutch has been found to be most effective, that is, a porcelain ring mounted in a sheet metal basket or punching. It is mechanically strong and will never carry current.

DASH POTS

Dash pots are of like importance and should be designed and manufactured with the utmost care. The cylinders should be as round and of as uniform diameter as it is possible to obtain them, valve seats should be accurately machined and the plungers fitted with the greatest care so that each dash pot will operate in about the same time as every other one. Also they must not be affected by wide variations in temperature. To meet these requirements practically all dash pots are now being made of graphite and brass, since graphite has a practically neglible temperature coefficient, and works excellently as a plunger in a brass cylinder.

SHORT-CIRCUITING SWITCHES.

The short-circuiting switch would seem to be a simple thing, but it may easily be a continual source of trouble, on account of the way it is abused, especially on inside lamps. In commercial service, lamps are generally hung fifteen or twenty feet from the floor and are seldom wired in such a manner as to be controlled by wall switches, so a long pole in the hands of a janitor is generally used to knock the switch back and forth. Such treatment demands a strong and simple switch. If there are no moving wires it is so much the better, as such wires harden or crystallize in the course of time and break off, making the switch useless until repaired. The best switch, therefore, is one fitted with a substantial handle, working between two positive stops and having a blade made entirely of insulating material with a contact button inserted in it, constructed in such a manner as to be forced between two stationary contacts to close the switch circuit and away from them to open. This, obviously, does away with all necessity for moving wires and provides a switch that is practically indestructible.

BINDING POSTS.

Binding posts also might be considered of small importance to a superficial observer, but they assume new proportions when we stop to think that in the case of series street lamps, for instance, they are exposed contacts carrying potentials as high as 10,000 volts, and in come cases they have to perform double duty and support the supply lines leading from the pole to the lamp. Practical operation has proven that these binding posts should be compactly built, fitted with two screws, drilled out for wire as large as No. 4 B. & S. gauge, and thoroughly protected by heat and moisture-proof insulation, preferably porcelain, arranged in the form of an insulator for outside service.

ALIGNMENT OF PARTS.

Proper alignment should be secured in a lamp by reason of the elements of its structural design. In other words, a lamp should be built so that it will be unnecessary to line it up after assembling. The parts should go together in such a way as to effectually take care of the alignment without further labor. If a lamp movement is not in proper alignment, trouble is to be expected from the upper carbon sticking, either in its guides or in the gas check center. One of the best ways to preserve alignment is to use a rigid center tube construction, with a sheath or holder inside of it for the upper carbon. In this method the sheath is connected in the circuit by means of a flexible conductor, which may be either inside or outside of the tube. The tube, however, must either be slotted or provided with some other ample means for ventilation. If this is not done the heat from the arc will be retained in the tube and will soon destroy the flexible cable. Various attempts were made in the early days of enclosed arc lighting to supply current to the upper carbon without using a cable, but one by one they proved their inadequacy and were discarded in favor of the cable which is the standard to-day.

GENERAL CONSIDERATIONS.

It is very gratifying to note that many of the features of lamp construction and design which have been outlined in this article, are being carried out to-day in the best modern practice, and that arc lamp buyers in general are beginning to discriminate against cheap lamps. The time is rapidly approaching when operating men will fully realize the importance of building a lamp of the best possible material, with the highest grade of insulation that can be obtained, combined with workmanship of a good quality, and painstaking shop inspection and testing. The question may be asked as to why all this is necessary, but a consideration of the conditions will make the reasons evident, especially on the high tension alternating-current series systems. Lamps for this service must operate on circuits of up to 100 lamps, with a potential of over 9,000 volts, and they must con-

tinue to operate in rain, sleet, snow, under widely varying temperature conditions and in the most exposed places. Other apparatus for such voltages is protected in every way possible by means of heavy metal cases, large porcelain insulators, and is immersed in oil wherever possible. All of these methods of protection are obviously out of the question in arc lamp design, yet alternating-current series lamps must not only withstand these voltages but must accurately separate and maintain an arc between a pair of carbons. Moreover, other exposed parts of a high tension equipment are held rigidly in some such place as on a pole or a building wall, while a lamp is at the mercy of every breeze or gale that blows, being supported in most cases at the end of a light mast arm, or at the center of a slender span wire. These operating difficulties certainly indicate that it is impossible to exercise too much care in the design, manufacture and operation of lamps for outdoor service.

CLASSIFICATION OF LAMPS.

In taking up the matter more specifically it should be noted that there are three broad classifications of arc lamps adapted to operate on the different commercial systems such as incandescent, power and street railway equipments. The first are generally styled multiple lamps and operate on 110 and 220 volt direct-current and 110 volt alternating-current constant potential circuits; the second class, series lamps, which operate on both alternating and direct constant current circuits, and the third class, which is a combination of the first and second, in which lamps operate in multiple-series on constant potential circuits. Practically all of the electrical and mechanical characteristics noted in the first part of this article are common to all of the commercial types of lamps, and in the brief specific descriptions which follow it should be understood that gas checks, clutches, dash pots, etc., have been described in detail and will only be mentioned in the descriptions as the need arises.

DIRECT-CURRENT MULTIPLE LAMPS.

On account of so many isolated plants using 110 volts direct-current and on account of many of the larger cities having 220 volt direct-current three-wire systems a large number of arc lamps suitable for direct-current constant potential circuits are in operation. Solid carbons are invariably used in these lamps, generally a twelve-inch upper and a five or five and one-half inch lower. From the circuit diagram, Fig. 1, it will be seen that this lamp consists essentially of a pair of carbons, a resistance and magnets for striking the arc. A dash pot, not shown in the sketch, is used to steady the arc. On the 110 volt multiple lamp, the resistance, B, is usually wound with enough wire to enable it to be used on circuits of from 100 to 125 volts and should be set so as to have an arc voltage of approximately 80. This resistance and the magnet spools should be as nearly fireproof as possible. Much trouble was occasioned with the first enclosed arcs by reason of the resistance, which generally consisted of spring-like coils of wire stretched just enough to separate the turns and prevent them from touching. Such resistances gave

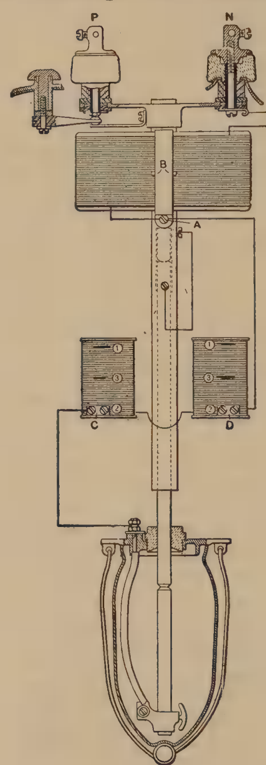


FIG. 1.—D. C. MULTIPLE LAMP.

very poor results, for, as they heated up, the wire in the coils lengthened sufficiently to short-circuit whole sections, with the inevitable destruction of the resistance and the lamp windings. The resistance spool shown in the circuit diagram does not have this defect, consisting as it does of a large porcelain spool with such deep grooves in its outer surface, that it is impossible for the heat to stretch the wire enough to short-circuit between grooves. Such a resistance, combined with magnet spools rendered as fireproof as possible, and proper structural details, make a very satisfactory lamp. The commonest trouble is improper arc voltage. If this voltage is more than 85, the arc is liable to be very unsteady and more of the resistance should be cut in; if lower than 75 the light is poor and the carbon tips oftentimes glaze over with a sort of slag formation which seriously in-

terferes with the proper maintenance of the arc. This condition, being the reverse of the preceding case, requires that some of the resistance be cut out. With the 220 volt direct-current lamp the arc voltage ranges from 140 to 165 at three amperes, according to the voltage of the supply. Both the 110 and 220 volt lamps increase the voltage at the arcs slightly when burning with chipped or broken inner globes, and the glassware should be inspected when long or unsteady arcs are observed.

DIRECT-CURRENT SERIES LAMPS.

Other lamps for the direct-current service are the series lamps for constant current circuits and the multiple-series for street railway and power circuits. The latter is practically the same as the series except that it has an arc compensating resistance which is cut in automatically if, for any reason, the lamp fails to start, thus maintaining the current as constant as possible for the remaining lamps in the series across the 500 or 220 volt mains. The circuit diagram, Fig. 2, shows the main features of this lamp—a series coil adapted to separate the carbons and strike the arc by lifting one end of a pivoted feed lever; electrically connected around the arc and arranged to work against the pull of the series coil, trip the clutch, and thus cause the carbons to feed together as they burn away. The dash pot performs its usual function in damping the movement and preventing fluctuations of the arc. The weight shown on the feed lever permits of accurate arc adjustment, being mounted on a threaded stud. A switch, not shown in the figure, is provided on the series lamp. Solid carbons are used in all cases and the arc voltage is approximately 80. The chief operating troubles are caused by unnecessary friction in the lamp mechanism and breakkage of glassware, which are really general troubles and are liable to be encountered on all types. It is a good rule to follow at all times in this class of apparatus, to have everything which moves reasonably loose and free. Close adherence to this rule will save many dollars in outages in the course of a year.

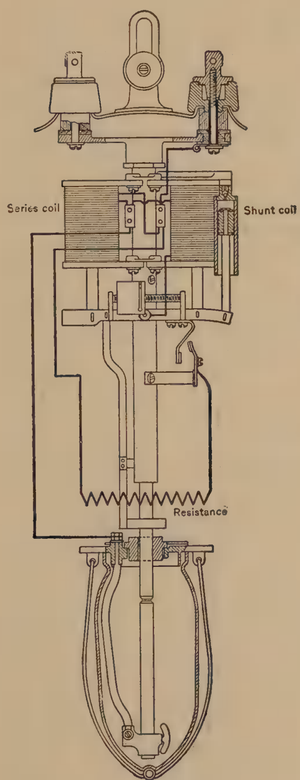


FIG. 2.—D. C. SERIES.

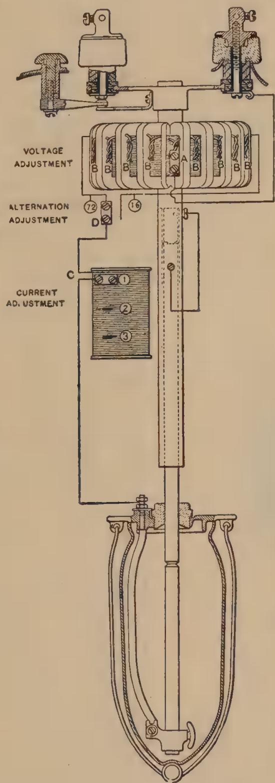


FIG. 3.—A. C. MULTIPLE.

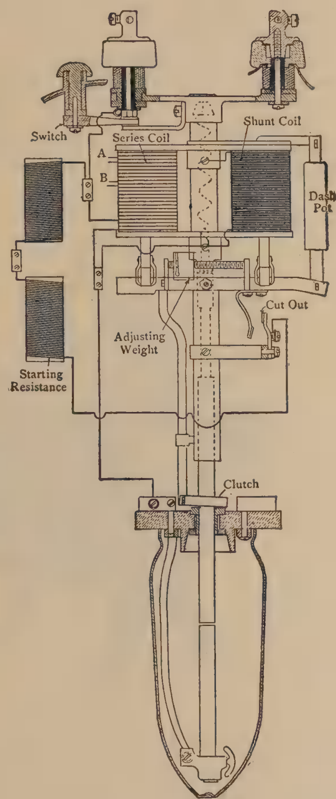


FIG. 5.—A. C. SERIES.

ALTERNATING-CURRENT MULTIPLE LAMPS.

The alternating-current multiple lamp is very similar to the direct-current multiple lamp and differs from it only in a few details. A reactance coil is used instead of the resistance and the magnet cores are laminated. This constitutes the chief difference from a structural view point. Fig. 3 shows the major details of this lamp. The voltage adjustment shown on the reactance coil allows for line voltages from 100 to 125 and the alternation adjustment makes it possible to use the lamp on any frequency from 16,000 to 7,200 alternations. In special cases these lamps are operated on circuits as low as 6,000 alternations; below this the alternations become visible to the eye, which is objectionable for general commercial lighting. It is possible to make an alternating-current multiple lamp almost fool-proof, which is without question a desirable attribute for any piece of electrical apparatus. This is largely accomplished by treating the coils so as to make it impossible to burn them out in a reasonable time even though the carbons should slip together. A lamp with this feature is certainly to be recommended, as the necessity for repairs to windings is almost entirely, if not quite, eliminated. The arc voltage on this lamp should be about 72 volts. If set much longer the lamp will rupture the arc and chatter, if much shorter the carbons will glaze and the light will be poor.

FIG. 4.—CONSTANT CURRENT A. C. REGULATOR.

ALTERNATING-CURRENT SERIES LAMPS.

The alternating-current series lamp is closely allied to the multiple lamp and has many features which are very similar. There never has been a more important advance made in arc lighting than was made by the introduction of the constant alternating-current series system suitable for operation on constant potential alternating-current bus bars. This was made possible by the constant current regulating transformer. It is primarily a transformer, receiving any commercial bus bar voltage and raising or lowering it to meet the demands of the circuit whether it be 50, 75 or 100 lamps; secondarily it is a regulator delivering a constant current from no-load to full-load. See Fig. 4.

The auxiliary apparatus pertaining to the alternating-current series system consists of a regulating transformer with the primary connected to the source of supply and with the secondary connected to the line. In this line the lamps are connected, together with suitable protective and switching devices, an ammeter, and a safety coil. From this coil, low tension leads are brought out making it possible to use the alternating-current series lamp for interior illumination.

The diagram of connections for the alternating-current series lamp is shown in Fig. 5, an inspection of which will make it evident that it is very similar to the direct-current series and multiple series lamp. The movement is a differential one with a starting resistance designed to permit just enough current to pass through the series coils to start the lamp, if the carbons are not burned out, in which case the resistance would carry the full working circuit, thus permitting the other lamps in the circuit to operate without interference. The automatic cut-out indicated in the figure is sometimes the cause of considerable trouble, and should be carefully designed. The cut-out has a phosphor bronze spring faced with coin silver contacts three-eighths of an inch square. Again, the center tube construction, as shown, gives great rigidity, insures alignment, and facilitates repairs, it being possible to take out the entire movement intact and completely assembled on the center tube. Care should be exercised to have these lamps adjusted to burn an arc of 72 volts, but readings should never be taken on arc lamps of any description, if accuracy is desired, until they have been in operation for at least two hours and are thoroughly heated. Such readings should also be taken with carbons that have been burned and are of an average length. In the case of alternating-current series lamps one carbon must be cored and the other solid. Cored carbons, however, are sometimes used for both upper and lower.

In general, careful attention to the length and size of carbons, accurate fitting glassware, and the habit of keeping the lamps free from dirt will be well repaid by more efficient operation and reduced outages.

THE DIFFUSING REFLECTOR

(*Continued.*)

By E. L. Zalinski.

(*Electrical Review.*)

It is this portion of the light which the diffusing reflector utilizes, to a large extent, and that, too, in a manner to secure better distribution. If the optical law stated by Mr. Elliott were entirely applicable to this reflector, the actual results obtained would have been very different.

Ordinary curves of distribution of light may be entirely correct, but they are apt to be misleading when it is desired to present the real efficiency of reflectors, since the radial distances deal only with the intensities of light. The Rousseau diagrams consider, in addition to intensities, the area of the surface illuminated. Thus, the illuminating power of a source of light is proportional to the area enclosed by the Rousseau curve.

Fig. 1 represents the Rousseau curves shown in Mr. Elliott's Fig. 4, omitting curve E, which is of a fifty-candle-power lamp, and, therefore, is not properly comparable with the others, which are for thirty-two-candle-power lamps. This curve brings out the advantages of the enameled reflector used in the subway for securing a remarkably uniform distribution. The same characteristic of relative uniformity of distribution applies to other pipes used in the subway, thus securing a more equable and inter-helpful light.

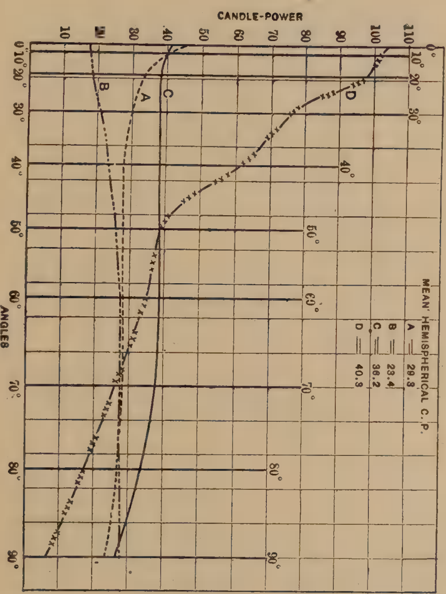


Fig. 1.—Rousseau Diagram.

Note: The cuts are placed so as to show the curves in their usual position.

In Mr. Elliott's Fig. 3 are given two curves of a reflector enameled on the outside; and a similar one painted on the inside; but he does not give the same prismed-glass reflector uncoated. This is unfortunate, since it would have given us an opportunity to make a direct comparison, and enabled us to show the marked gains secured by prismed-glass reflectors with the enamel or the paint backing, applied either inside or outside. The Rousseau curves of these reflectors show a character of distribution superior to anything obtainable by a clear glass-prismed reflector.

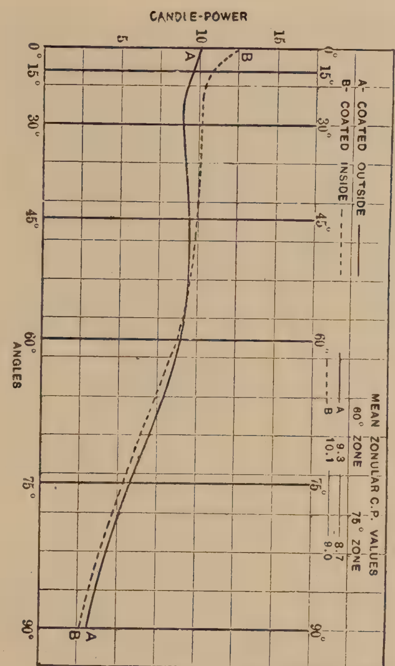


Fig. 2.—Distribution of Light with a Reflector Coated on the Inside and on the Outside with Enamel.

In my early experiments I obtained analogous results when the paint on the inside was fresh and glossy, and the results were lower in efficiency when the paint was dried. I found paint inferior to enamel, both for durability and appearance; but when suitable enamel was used, either inside or outside, on absolutely similar reflectors, the results were practically identical. Each had a slight advantage at one end of the curve, but compensated for this at the other. This effect is shown, in a

measure, in Fig. 2, but is also in evidence in numerous other measurements.

Many measurements have been made, with various classes of reflectors, in endeavoring to learn how these might be improved. It was evident that the goal to be attained was to broaden the distribution. It is not difficult to secure *depth* of curve—that is, intensity of illumination—by modifications of shapes of the reflectors, but it is not as easy as Mr. Elliott claims, to secure broadened distribution by so doing. For these tests, prismed-glass reflectors were made from the same mold, but given different angles of aperture while in the plastic state.

Fig. 3 represents curves of distribution

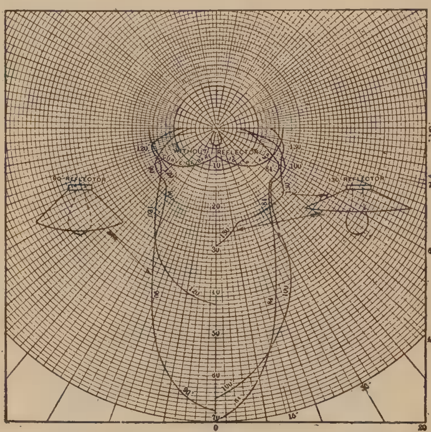


Fig. 3.—Distribution with Prism-Glass Reflector with Different Angles of Opening.

of light about prismatic-glass reflectors having angles of aperture approximately eighty-four degrees, ninety degrees, 100 degrees, 120 degrees and 130 degrees, respectively. These curves show that the increased angle of aperture results in decreasing the downward distribution, with no appreciable increase in intensity in their higher angles. Investigations made to determine how the opening of the reflectors affects the reflecting capabilities of the prisms, demonstrated that there is no appreciable loss due to this; and, in fact, in some cases, a slight gain was found.

A study was made of reflectors of various shapes and material. The curves from these reflectors showed that the porcelain reflectors secured an advantageous distribution, but were lacking in intensity. The prismed-glass reflectors have great intensity, but were lacking in breadth of distribution. The latter also were objectionable on account of their injurious and disagreeable glare when viewed at certain angles. The relative efficiencies and the character of the distribution of these types of reflectors are shown in Fig. 4. Curve "A" shows the distribution of an eight-inch porcelain reflector, and curve "B" that of an eight-inch clear-glass prismatic reflector. The character of the curve of the white porcelain reflector is evidently chiefly due to diffusive action, while that of the clear-glass prismatic reflector may be characterized as reflection.

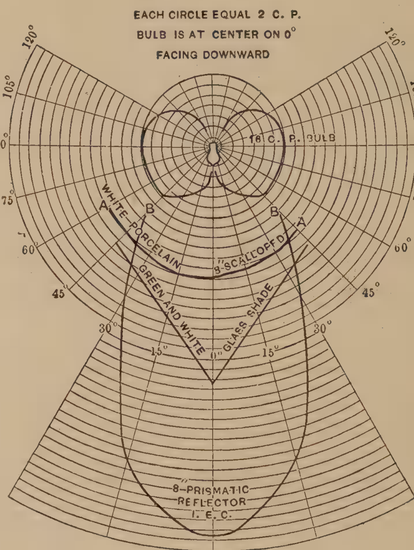


Fig. 4.—Illumination with Eight-Inch Prismatic Reflector; Ten-Inch Green and White Shade; Eight-Inch White Porcelain, Scalloped.

In order to make clearer the distinction between diffusion and reflection of light, I quote the distinction given by Professor William Hallock, of the department of physics, Columbia University.

"I do not see how any one can contend that diffusion and regular reflection are the same phenomenon. Of course, one may say that they are both due to difference in the optical properties of two media. Nevertheless, it is generally understood that by reflection we mean the case where the majority of the light is sent off at an angle equal to that of the incident light, and all in one direction. Scientifically stated, it is the case where the light, on leaving the surface, has a simple, well-defined wave front. In diffusion, the light, leaving the surface, goes off in directions bearing no relation to the direction of the incident light; in fact, in all directions in a general plane of incidence. In this case the light has no simple, well-defined wave front, but a complex multitude of little waves travel-

ing in all directions and not uniting in one general wave."

From the preceding investigations the conclusion was arrived at that the distribution might be made better by coating the prismed-glass reflector with white porcelain, enamel, or other light-diffusing material, retaining at the same time a considerable portion of the directly downward intensity of light. Such coating also tends to reduce the injurious and disagreeable glare of the clear-glass reflectors, and better satisfies æsthetic and artistic requirements. The enamel used finally is sufficiently translucent to prevent dark spots above the reflectors.

In Fig. 5 are shown the results of the experiments. This gives the curves due to various similar thirteen and one-half-inch reflectors with three oval-filament lamps, in a Benjamin cluster. The curves relate to the following reflectors: "A" is the distribution of light given by a clear-glass prismed reflector; "B" shows the result with an opal reflector alone; "C" shows the combination of an open reflector, superimposed on the clear-glass prismed reflector; "D" shows the distribution produced by the clear-glass prismed reflector with a backing of special white paint No. 1; "E" is the curve for the same reflector with an enamel coating. In all cases, care was taken to have the planes of the oval filaments of the lamps parallel to the surface of the reflector.

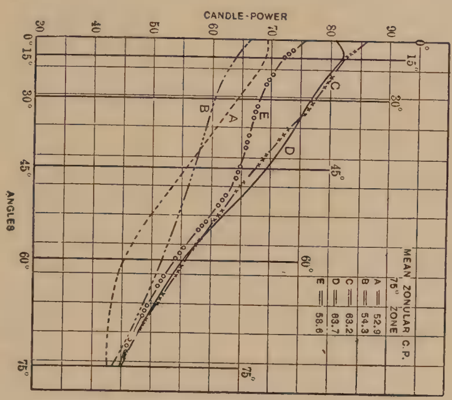


Fig. 5.—Rousseau Diagram, Illumination with Various Thirteen and One-Half-Inch Reflectors.

The plain prismatic glass gives 52.9 candle-power as an average throughout the lower seventy-five-degree zone. The opal reflector gives 54.3 candle-power, and the combination of the two gives 63.2 candle-power, a greater value than either alone. The reflector coated with white paint No. 1 gives 63.7 candle-power, greater than the combination of plain prismed glass and opal reflector. The reflector coated with enamel gives 58.0 candle-power. In the cases of the painted and enamel-coated reflectors, most of the values given by the plain prismatic-glass reflector, due to its action in reflecting the light are retained, plus an addition due to the diffusive action of the coating of paint or enamel; and it is to be noted that the gain in efficiency due to the superimposed coating more than counterbalances any loss due to prismatic reflective action, being assumed to be reduced as a result from the application of the coating on the glass prism. The reflectors used in these cases had about 140 degrees aperture. The clear-glass prismed reflector gives results inferior even to those obtained with the opal reflector.

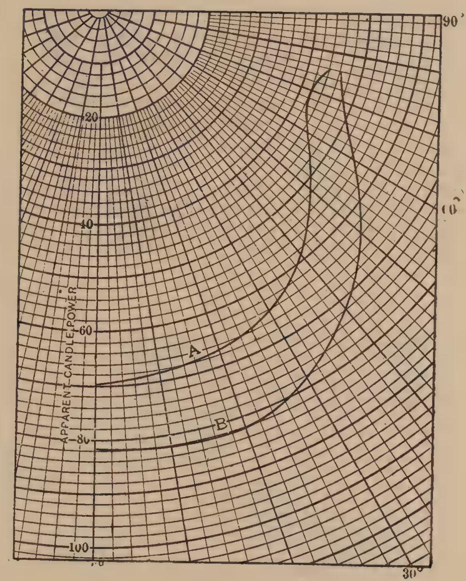


Fig. 6.—Distributor About Three-Lamp Clusters with Clear-Glass and Coated-Glass Reflector.

The relative values of the clear-glass prismatic reflector and the same backed with white paint No. 1 are shown in distribution curve Fig. 6. The enamel prismatic glass does not give quite as favorable results as does the painted one, but gives better results than either prismatic glass or opal alone. This tends to prove the contentions, that the prismatic-glass reflector receives reinforcement by the light-diffusing action of the white enamel, as it clearly does when backed by the proper coatings of white paint. It also gives a marked improvement in the changed and

bettered distribution, and the avoidance of glare below, dark spots above, and generally improved appearance. The advantages gained by the use of a diffusing coating is shown in curve "B," curve "A" being that of a similar clear-glass reflector (see Fig. 7).

The gain due to the action of the diffusing coating is not shown entirely by the added values in candle-power. The average values may even be identical, but in the one case we may have high values—too high for comfort—over one part of the field, and values too low over the other parts. The gain is very largely in the better general distribution obtained, which cannot be well expressed numerically. An inspection of the curves presented will convey this better than can the average values expressed in figures. To put these values in a manner which will convey a just conception, it is suggested that the mean values be stated as at present, with the maximum and minimum values given in the zones from zero to ninety degrees, placed one over the other. For example, the value of curve "D" (Fig. 6 of Mr. Elliott's article) would, according to this classification, be 40 104/6 candle-power; and curve "C," similarly, would be 32.2 40/26 candle-power. The former implies

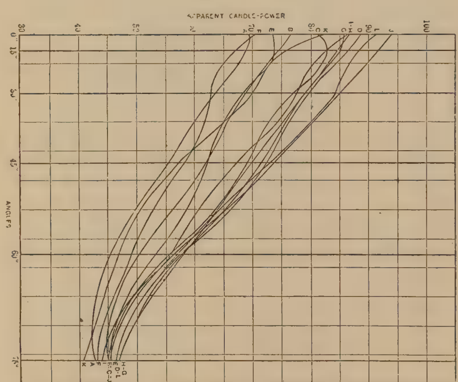


FIG. 7.—DISTRIBUTION OF LIGHT, WITH DIFFUSING AND VARIOUS OTHER REFLECTORS.

a value of sixty-four candle-power above, and thirty-six candle-power below, the mean value. The last would mean 4.8 candle-power above, and 10.2 below, the mean value.

Further experiments were made, showing clear prismatic-glass reflectors with coatings of white blotting-paper, blotting-paper pulp, asbestos, mineral wool, spun glass, and superimposed white opal reflectors, together with various kinds of enamel and paint. The results are shown in the Rousseau curves reproduced in Fig. 7. All of these tests were made with a thirteen and one-half-inch prismed-glass reflector with about 140 degrees opening, having a Benjamin cluster with three oval-filament, sixteen-candle-power lamps. The lamps were adjusted so that the planes of the filaments were, as nearly as possible, parallel to the inner surface of the reflector.

The results are given in the following table. It should be noted that for curve "I," a fourteen-inch opal reflector was used, the outer edge of which was covered with black tape to reduce the reflecting surface to thirteen and one-half inches in diameter.

The question arose, whether the improved results shown by the coated reflectors were due to increased reflection or to diffusion. To test this, a second clear-prismed glass reflector was closely superimposed upon the first. The results are shown in curve "K." At zero degrees the curve is somewhat high, but it rapidly falls to a minimum. This appears to show that the improved results were due to diffusive action of the superimposed reflectors or the white or whitish coatings. As is seen, such coatings tend to maintain the curve relatively high until the ninety degrees is attained, meaning that the light is distributed over a broader field than when the curve at zero degrees and adjacent angles shows a higher candle-power, after which it falls off rapidly.

Further investigation showed that the direct gain in candle-power in the lower hemisphere, probably due to the added diffusive action, was varied somewhat according to the shape or angles of the opening of the reflector. The wider openings gave better aggregate relative results with the diffusive coatings than did reflectors of smaller openings. The former are particularly advantageous in cluster lighting, where the lamps are placed radially, close to the surface of the reflector. But in all cases there was a decided improvement in distribution of the light, while the total available candlepower was about the same, or a little greater, even with the smaller-angled reflectors. Fig. 8 shows this effect. The curves here represented are for smaller reflectors. This figure is also of interest in showing again that the prismatic white-coated reflector gives better results than a plain opal reflector or a plain prismatic-glass reflector of simlar angle of aperture alone. In this figure, curve "A" is the distribution of an approximately right-angles opal reflector of seven and one-quarter inches diameter; curve "B" is the distribution for a similar plain prismatic-glass reflector seven inches in diameter; curve "C" is the effect of these two reflectors combined, the opal reflector being superimposed; curve "D" was obtained with a white enamel-coated prismatic-glass reflector similar to the reflector used for curve "B." The opal reflector has at least 5 per

Results Secured with Various Reflecting Surfaces—(See Fig. 7).

Characters of Reflectors and Backing.	Mean Intensity for 75° Zone of Lower Hemisphere. Candle-Power.	Variation of Intensity for This Zone. Per Cent.
Test A—Clear prismatic glass reflector only	52.9	Basic value
Test B—Clear prismatic glass reflector backed by similar white reflector	57.8	+ 9.3
Test C—Clear prismatic glass reflector with white paint on back	63.7	+20.4
Test D—Clear prismatic glass reflector with white blotting paper on back	65.8	+24.4
Test E—Clear prismatic glass reflector with white paint No. 2 on back	59.1	+11.7
Test F—Clear prismatic glass reflector with dust on back	55.7	+ 5.0
Test G—Clear prismatic glass reflector with blotting paper pulp on back	66.2	+25.0
Test H—Clear prismatic glass reflector with mineral wool on back	65.6	+24.0
Test I—Clear prismatic glass reflector with white opal superimposed	63.0	+19.0
Test J—Clear prismatic glass reflector with spun glass on back	67.4	+27.0
Test K—Clear prismatic glass reflector with another clear glass superimposed	55.7	+ 5.0
Test L—Clear prismatic glass reflector with asbestos wool on back	67.1	+27.0
Test M—Opal reflector only	54.3	+ 2.0
Test N—Clear prismatic glass coated with enamel inside, heavily	59.6	+13.7
Test O—Clear prismatic glass coated with enamel inside, lightly	56.5	+ 7.0

cent. greater area than the plain-glass reflector.

The same comments apply to these curves as to those shown in Figs. 5 and 7.

It may be added that, acknowledging the correctness of the optical law quoted by Mr. Elliott, it is fair to assume that the enamel coating has a different index of refraction from the clear glass, and therefore the law cited does not apply. The enamel fuses at a lower temperature than the glass, and is thus applied without destroying the smooth reflecting surface of the prisms.

It is inevitably the case, when practical results do not accord with theoretical dogmas, that these last are either wrongly stated or wrongly applied. The statement made by Mr. Elliott as to crown glass and balsam is correct, as these two have the same index of refraction (1.53); but it is overlooked that the indices of various clear glasses differ, such as, for example, flint glass—1.58; thallium glass being as high as 1.75, etc. Although enamel is vitreous, it need not from this fact necessarily have the same index of refraction as the glass; indeed, it would appear at the outset that this translucent, but not transparent, material would be likely to have a different index of refraction from the clear glass used in the reflectors on which it is superimposed. And this appears to be substantiated by actual measurements—for, superimposed on the clear-glass prismatic reflector, it secures results superior to this clear-glass prismatic reflector above, or to the reflector of opal, to which latter Mr. Elliott likens it.

The results given above show clearly that there is some gain in the amount of light made available by the diffusive coating, since it acts upon light otherwise lost. But the more important gain is the better distribution obtained by the use of reflectors with a diffusive coating either inside or outside.

It must be obvious that it is better to have, at zero degrees, a moderate but sufficient degree of intensity—provided it is well maintained—than to have an intensity highest at this point, decreasing rapidly toward the upper zones. By so doing we avoid the objectionable contracts resulting from very dark and light spaces.

It was not expected, by the use of the diffusive coating to other similar methods, to create light; but the effort was made to avoid having it all in a limited space, and to modify the distribution so as to secure the maximum benefits. In other words, it was attempted to put the light where it would do the most good, and to avoid a superabundance in one place, with the resulting, and equally harmful, contrasting insufficiency in others.

FOREIGN ITEMS

England does not seem to have yet realized to any extensive degree the dictum of their great engineer, Stevenson, that "where combination is possible, competition is impossible." The companies furnishing illuminating gas and electric current for lighting purposes are apparently very genuine and aggressive competitors, and the technical and trade journals devoted to the respective industries are stout champions of their individual causes, each gathering with all the ardor of a politician the material that favors its cause, and holding up to the public scorn the shortcomings of its competitors.

At the March meeting of the Illuminating Engineering Society, Mr. Victor Rettich presented a paper on the Inverted Incandescent Gas Burner, in which he enumerated the difficulties that were to be met with in bringing this burner to a practical issue, and concluded that, whereas, not all of these difficulties have as yet been overcome to the entire satisfaction of the manufacturers, the manifest advantages to be gained, and the progress already made are so great that its ultimate perfection was to be looked for. The *Electrical Review,* however, finds material for much ghoulish glee in this unbiased description of the inverted gas burner.

It is to be hoped that we shall soon have an Illuminating Engineering Society in England. One of the advantages of bringing together on common ground men whose business it is to push diverse forms of illuminants is that, whatever statements they may be guilty of during the day-time, in the evening they discuss their pet lamps with a freedom that is positively brutal. At least, so it appears to be in New York, where, at a recent meeting of the Illuminating Engineering Society, Mr. Rettich, a gas engineer, gave away completely the case for the inverted gas mantle lamp. We have only to call to mind the Gas Exhibition at Earl's Court about 18 months ago, when the inverted mantle held a veritable orgy of shameful imitation of electric light; when London was "papered" to see the new substitute; and when certain station engineers were seized with a panic of which one of the healthiest outcomes was the Olympia Exhibition. And now we learn that the lamp is found wanting in many respects: dangers of falling particles; carbonization; flashing back; delicacy of mantle suspension; flickering at low pressure; discoloration of chandelier arms; too much heat thrown off in proportion to amount of gas used; unpleasant noise, etc. The indictment is a long and severe one, and we may add that our own experience completely confirms it. The author stated that the lamp had recently been condemned in New York by the Board of Fire Underwriters on account of fires started from it, and tables, etc., had been charred by red-hot material falling through the base of the globe. Wherever one goes it is apparent that the inverted gas mantle has not "caught on"; inquiries at ironmongers show that the demand for these lamps is very small indeed, and orders are seldom repeated; and it has been clear for some time that the gas companies put their money on the wrong horse, whilst they obtained for the time a very successful bogy. Like many a turnip with a very poor candle. The others, this has been proved to be merely breakage of mantles due to vibration makes the lamp an expensive one to maintain, the roaring and bubbling is very irritating, and the fittings rapidly deteriorate owing to the great heat evolved. It is satisfactory to note that electricity supply authorities have held their own, and we have reason to believe that the gas companies will have their work cut out to do the same in connection with coming developments in high-efficiency electric incandescent lamps.

At almost the same time that Mr. Rettich was giving the electrical interests this ammunition, a paper was presented before the (British) Institution of Electrical Engineers by George Wilkinson on "Waste in Incandescent Lighting, and Some Suggested Remedies," which we reprinted in our last issue. Mr. Wilkinson, it seems, is a manufacturer of incandescent electric lamps and knows whereof he speaks; and in his very full paper on the subject, in which he sets forth the shortcomings and misuse of the electric lamp, gives the *Journal of Gas Lighting* an opportunity to reply:

As usual during the winter season, the Local Sections of the Institution of Electrical Engineers have given forth a mass of technical matter, the greater part of which does not call for notice by us. From among the papers, a couple have been placed on one side for notice. To one of them, by Mr. George Wilkinson, on "Waste in Incandescent Electric Lighting, and Some Suggested Remedies," there has already been incidental reference. As competitors of electricity, it may be openly confessed that the question of whether or not consumers of electricity get the expected value for the money they expend, is not a matter of indifference to us. Testimony that they do not recurs with a frequency that cannot be pleasant for those station engineers who would fain hide the truth. Mr. Leon Gaster has twice of late publicly given voluminous confirmation of the general experience of the inconsistency of electric carbon-filament lamps—of the fact that they do not do what the markings on them declare they should do, of their rapid depreciation, and of the detrimental effects of irregularities of voltage, the correctness of all of which Mr. Wilkinson attests. His paper is full of deprecation of incorrectly graded and inefficient lamps, and of the persistent use of lamps after they have become blackened on the inner surface of the globe. So marked is the lamentable waste, and "its effect upon the future of electric lighting is so serious," that it is, he holds, high time some definitely-concerted action was taken by the supply authorities throughout the country to deal effectively with the matter, and to educate every consumer so that he may know how to get efficient electric lighting at reasonable cost.

The formation of the Illuminating Engineering Society in this country, and the appearance of THE ILLUMINATING ENGINEER, have attracted wide attention among those interested in the various fields of illumination. The following extracts from foreign journals indicate their views on the subject:

(From *Electricity*, April 27, 1900.)

I have just received the first number of a new magazine called the ILLUMINATING ENGINEER, published by the Illuminating Engineering Publishing Co., New York, a periodical which will be devoted entirely to illumination as a science and an art. In the Editorial Foreword I learn that the means of producing light from various sources, such as electricity, illuminating gas, etc., will receive a due amount of attention, together with improvements in accessories and apparatus for distributing and diffusing light after it is produced. It is pointed out that, although the money expended in the production and use of light assumes enormous proportions, yet it is safe to say that in no other department in modern commerce is there so much money expended with so little knowledge of the best methods of obtaining the desired results. Our present methods of lighting are undoubtedly extremely crude, and it is not altogether the fault of the architect or the consulting engineer that it is so.

In giving instructions for lighting his premises a client will often say, "What I want is plenty of light," and by plenty of light he means that his place must look brilliant and attractive. This is, of course, not economy in the sense of getting the best value of the light for illuminating purposes, although in many cases the indirect advantage of advertisement may not be inconsiderable. But in ordinary house or office lighting there is a very considerable room for improvement. The method of hanging lamps from ceilings so that a point of light strikes high immediately upon entering the room is one of the worst possible methods, because the eye is immediately dazzled and the optic nerve is to some extent paralyzed, and objects which, if the light had been shaded, would have appeared sufficiently illuminated, have the appearance under the circumstances of being comparatively dark and insufficiently lighted. Just as the highest form of art is to conceal art, so the most effective and economical methods of illumination are to conceal the source of light whilst throwing the maximum amount of illumination on the objects to be lighted.

It is for this reason that the reflected arc lighting is at present becoming again so popular. By this system, a very diffused and practically shadowless light is obtained without glare, and it is a beautiful light to work by. There is, however no doubt that this is an uneconomical method of lighting, owing to the double loss of light in the double reflection, first from the bottom reflector, and then from the ceiling. The most economical method is, of course, one in which the light rays are thrown directly upon the objects to be lighted, the source of light thus being shaded or concealed. Considerable progress has been made in this direction in the matter of shop-window lighting.

(From *Electrotechnik und Maschinenbau.*)

This movement deserves our own attention, since innumerable cases of inartistic, unpractical and unhygienic illumination are to be observed, and the study of these questions by specialists would lead to betterment and to a further growth in the use of electric illumination. Would it not be advisable, for instance, for our larger central stations to put the services of such an engineer at the disposal of their consumers, and especially their prospective consumers?

THE NEED FOR THE ILLUMINATING ENGINEER

LEON GASTER, in the *Electrical Magazine.*

The recent comments published in this journal dealing with the necessity for the professional illuminating expert, and your kind invitation to express my views regarding this subject, are my main reasons for sending you the following article.

Until recently insufficient attention has been given to the systematic application of the scientific principles of artificial illumination, the degree of illumination desirable for different purposes, and the disposition of light sources for artistic effect. All these have been mostly ignored, or to say the least, on account of lacking exponents, have not been accorded the prominence due to them. The different purposes for which artificial light is required call for special treatment if the best results are to be obtained, and it is therefore regrettable to note that in many cases recourse has been had, for effect, to extravagant illumination without due regard to expense, or the effect on the eyes from the glare. The reverse has happened in other cases, so that little light has been used on account of cost, and even that has not always been turned to the best advantage.

My object in writing this article is not to make a wholesome complaint, but if possible to indicate how in time to come, this deserved reproach of neglect may no more be justifiable. Considerable work has already been done by several investigators *re* the absorption and distribution of light from shades, globes, and reflectors. The data obtained on this subject are, however, very much scattered, and no uniformity exists in the results of the reported tests. The great variety of systems of photometric measurement and apparatus used by the different observers explain, to a certain extent, the reason for these differences. The value of engineering data of this kind lies largely in their use for making comparison of one reflector, shade, or globe with another, and it is therefore gratifying to find that recently Messrs. J. R. Cravath and V. R. Lansingh have drawn all their data, published in their admirable articles *re* reflectors, shades, and globes in the *Electrical World*, from tests made in a single laboratory. The results of these tests are therefore of great value for comparison. The immediate practical application of the data given is evident, when one considers the great improvements which can be obtained in planning illumination by incandescent lamps, by knowing what types of reflectors, shades and globes have to be selected, so as to change the natural distribution of light from the bare source for the accomplishment of a desired effect. In examining many of the existing installations, one is often struck by the awkward position in which the lamps are placed, which can hardly be traced to the former use of gas and gas fittings.

Much has been done by central station engineers to bring down the prices at which electrical energy can be generated by adopting improved methods of power generation. Although there is still a great possibility for further reducing the price of the current in the future, the immediate economy to the consumer, however, lies in properly studying the selection of the most efficient type of lamps, by the careful distribution, and by a selection of shades and reflectors, and for this purpose the future illuminating engineer can come to his assistance. The present gap which seems to exist between the supply authorities and the consumer demands the creation of a distinct illuminating engineering profession which will be expected to make a special study, not only of the merits of electric lighting, but be also well acquainted with the merits and faults of the other systems of illumination. Only from such experts can one reasonably expect unbiased opinions as to the best systems of lighting to be adopted. Very often one is confronted with the problem of deciding whether gas, oil, or electric light is best to be employed, and only by properly studying the circumstances of the case, viz., the price per unit of electric energy charged, that of gas or oil, and the purposes for which the light is to be utilized, etc., is one in a position to decide what system would be best and most economical to adopt. For the present it is hardly possible to find that expert engineer of whom we are speaking now, because he is, as a rule, either interested in electric lighting or in pushing the gas interests, and we find that according to his inclination he may be biased in his decision. Moreover, it might appear in a good many cases that a combination of two systems would prove economical. Such cases have frequently come before my notice, one part of the work using gas, and the other using electric light, but it is difficult to find at present the engineer to recommend the use of both systems.

Gas engineers have nursed their consumers much more by looking after the lighting business, greatly extending the use of mantles, and have made the gas lighting what it is. There is, however, I believe, still more to be done in this respect by gas engineers. Some think that great economies are to be derived in the future from further improvements in the manufacture of gas, and from the gas companies being relieved of the duty of producing gas of specified c. p. They would prefer to use the gas as a heating agent, and, indirectly, for lighting purposes, as in use of gas mantles. Then gas would be cheaper, and it would find more extended use also for heating and motive power purposes.

THE EFFICIENCY OF LAMP GAS GLOBES*

By F. C. Prentice and J. S. Westerdale.

The first portion of the paper contains an account of previous work which has been done on the subject of the efficiency of globes. Dr. Sumpner in a paper entitled "The Diffusion of Light" (*Phil. Mag.*, February, 1893) (see also *The Electrician,* Vol. XXX., pp. 381, 411 and 439), tested three globes which absorbed 15, 42 and 39 per cent. of the light respectively. Experiments of Messrs. Guthrie and Reidhead are given by Mr. G. D. Shepherdson in a paper on "The Loss of Light from the Use of Globes with Arc Lamps" (the *Electrical World,* 1894). Mean spherical and mean hemispherical candle-powers were measured and the efficiencies of clear, ground glass and opal globes are given as 73.8, 50.2 and 45.2 per cent. for mean spherical and 72.4, 47.8 and 30.7 per cent. for mean hemispherical candle-power respectively. The authors, however, point out some possible causes of error. A paper by Stort (*Elektrotechnische Zeitschrift,* 1895), however, gives the loss of light with a clear glass globe as 6 per cent. and that with an opal globe as 11 per cent. Experiments by Williamson and Klink, published in the *Journal* of the Franklin Institute (Vol. CXLIX., 1900), dealing mainly with the distribution of light by "holophane" and other globes are next referred to, and after mentioning the article by Mr. M. Solomon on "Some Tests on Lamp Globes" which was published in *The Electrician,* November 3, 1905, p. 91, the first portion of the paper concludes with a reference to a series of articles by Cravath and Lansingh on "Reflectors, Shades and Globes," which recently appeared in the *Electrical World.* In a few of these investigations, however, were polar curves of light distribution made on arc lamps surrounded by globes, so it was with this idea that the authors' experiments were carried out, at the instigation of Prof. J. A. Fleming, in the "Pender" laboratories at University College.

Arrangements were made so that the beam to which the arc lamp was attached could be rotated to any angle about a center which carried a plane mirror, situated in the axis of the optical bench. The arc was inverted to facilitate removal of the globes, and care was taken to keep the P.D. constant at 50 volts and the current constant at 6 amperes. Each observation given in an average of several readings, and the coefficient of reflection of the mirror, were accurately determined and allowed for. As secondary standards, a series of ordinary incandescent lamps were used and these were calibrated against a Fleming large bulb incandescent lamp having a known candle-power at a known current. A fixed Lummer-Brodhun prism photometer was used, the secondary standard being moved to obtain a balance. Figs. 1 to 4 give a set of polar diagrams for four of the cases investigated. The "Rousseau" curves were deduced from these in the usual way. The mean spherical and mean hemispherical candle-powers obtained from these diagrams are given in the following table:—

Globe.	Mean spherical c. p. Arc only.	Mean spherical c. p. Arc in globe.	Mean spherical ratio. Per cent.	Mean hemi-spherical c. p. Arc only.	Mean hemi-spherical c. p. Arc in globe.	Mean hemi-spherical ratio. Per cent.
13-in. alabaster	346	339	98.0	592	473	79.9
13-in. clear	346	308	89.0	592	520	87.9
13-in. opalescent	342	343	100.0	288	238	82.8
12-in. prism	342	306	89.5	288	250	86.9

Referring to the polar curves, it is seen that in the case of the uncovered arcs the candle-power drops very rapidly after about 70 deg., owing to the effect of the negative carbon cutting off light from the crater of the positive carbon. But in the case of the alabaster and opalescent globes, the globe itself becomes to a certain extent the source of light, owing to dispersion, so that when the globe is on we get a measurable candle-power right up to 180 deg. There is another important reason why the candle-power in directions above 90 deg. is greater with the globe on than with the arc alone. Light from the crater falls on to the lower parts of the globe and is partly reflected back. This reflected light is partly emitted through the upper part of the globe, thus increasing the candle-power in these directions. The opalescent and alabaster globes cut off a large percentage of the light. This, however, is not all lost, but, being partly dispersed and partly reflected back, increases the candle-power in the directions where for the arc alone it would be either nothing or very small. This accounts for the high values of the mean spherical ratio obtained. From the curves we see that in the directions where the candle-power of the arc is greatest the opalescent globe cuts off more light than the alabaster, even though it is not

* Abstract of paper read before the Students' Section of the Institution of Electrical Engineers, March 14, 1906.

so dense. This is due to its power of selective dispersion. The yellow rays pass through the globe, but a great part of the blue rays are reflected back and help to increase the candle-powers in the top part of the curve. For street lighting, all light above the horizontal is useless, so that globes that disperse the light well through the 180 deg. are unsuitable, although the mean spherical ratio may be great. The mean hemispherical ratio is the more important in this connection. The clear glass and prism globes have the highest mean hemispherical ratios, so that for street lighting these globes would be more suitable.

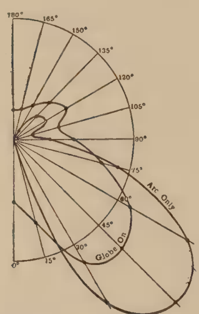


FIG. 1.—PHOTOMETRIC CURVES FOR 13 IN. ALABASTER GLOBE.

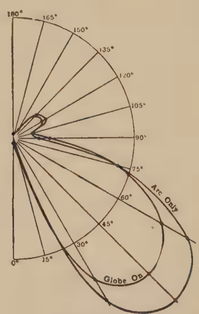


FIG. 2.—PHOTOMETRIC CURVES FOR 13 IN. CLEAR GLASS GLOBE.

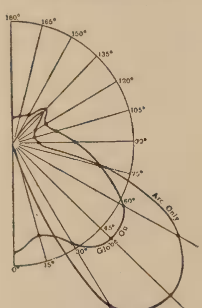


FIG. 3.—PHOTOMETRIC CURVES FOR 13 IN. OPAL GLOBE.

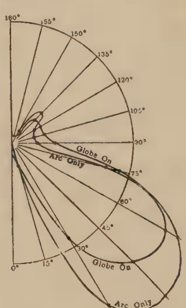


FIG. 4.—PHOTOMETRIC CURVES FOR 12 IN. PRISM GLOBE.

WORKSHOP ILLUMINATION. PRACTICAL CONSIDERATIONS GOVERNING THE EFFICIENT LIGHTING OF WORKSHOPS BY ARTIFICIAL APPLIANCES.—An abstract of a paper presented before the Coventry Engineering Society by Mr. A. E. A. Edwards.

Attention is called in this article to the most obvious necessities and faults of general shop lighting. The advantages of providing light-colored or white walls and ceilings in order to produce diffuse reflection are set forth. "It is computed that with a room of which the interior is painted white a 20-candle-power lamp will give the same illumination as a 100 candle power lamp in a room with black surfaces." The basis of this computation is evidently the statement made later in the article, that white surfaces reflect 80% of the light. This figure is far too high, however, in practice, especially for walls in factories, which must soon become more or less soiled. It is even suggested that the machinery itself be painted white or light color instead of the usual dark gray.

The absorption of light by the various sorts of diffusing glass are stated and attention is called to the loss due to collection of dust and dirt on globes, etc.

The following advice as to the ordinary flat flame gas burner is to the point and well worth heeding:

"The light we get from a burner does not depend altogether on the amount of gas that is passed through it. For instance, if we take two gas jets burning in an ordinary manner, and place them side by side, so that the two flames intermingle, the candle-power of the resultant flame is much greater than the candle-power of the two flames burning separately. In an ordinary union-jet burner there are two holes fairly close together. After use these holes alter in size and shape, and the lighting power of the jet rapidly deteriorates; these burners usually give 1¼ to 1½ candle-power per cubic foot of gas used per hour, while a good steatite burner gives 2½ candle-power per cubic foot. The inference to be drawn is that as soon as the shape of the gas flame has become altered you may know that you are using that burner at a low efficiency, and it will pay you to throw the burner away and to put on another."

The blackening of incandescent electric lamps from overstrain is dwelt upon and a "warning is given against buying and using these so-called very high efficiency lamps." "Arc lamps, like all other sources of light, should be so placed that the eye does not catch sight of the lamp while the workman is engaged in his occupation, although on the other hand they must not be 'skyed' for reasons already given." A number of the conditions dealt with in relation to incandescent electric lamps do not apply to this country.

HOW IS THIS FOR MUNICIPAL OWNERSHIP?

(From *The Electrician*, April 6, 1906.)

MUNICIPAL WIRING.

London County Council (General Powers) Bill.

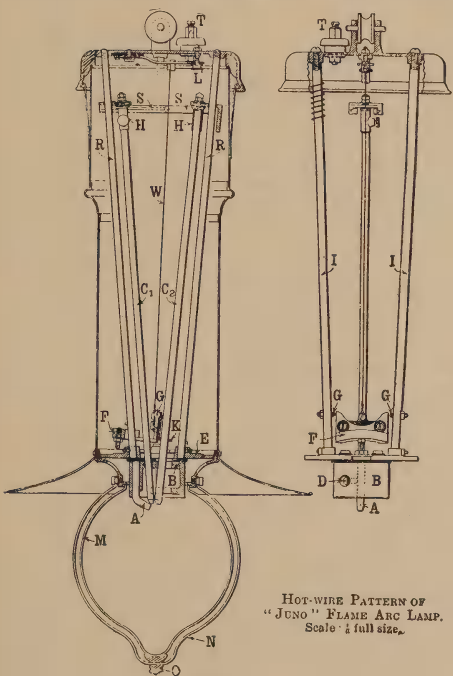
"It shall be lawful for the council of any metropolitan borough being authorized to supply and supplying electrical energy to expend money upon the wiring and supplying with wires and fittings, motors and apparatus the premises of their consumers or prospective consumers, and to enter into and to carry into effect agreements and arrangements with respect thereto, and to make such charges therefor as they may see fit."

A NEW FLAME ARC LAMP

(*Electrical Review.*)

Electric arc lamps designed to utilize the heating effect of the current have often been tried in this country, but judging from the fact that they have never come into practical use, have been unsuccessful. The principle however, being so simple, offers an attractive field for experiment, and has been utilized in a form of lamp called the Juno, which has reached a commercial stage in Europe.

The "Juno" flame arc lamp, which has recently been designed and placed on the market by Messrs. Johnson & Phillips, of Old Charlton, is remarkably simple in con-



Hot-wire Pattern of "Juno" Flame Arc Lamp. Scale · ¼ full size.

FIG. I.

struction and operation, as will be gathered from the sectional drawing, Fig. 1. At present it is made in one standard size, which is stated to emit about 2,300 c. p. (mean spherical) at a consumption of 450 watts. Four lamps of the type described below will burn in series across a 240-volt supply.

The carbon C_1 does not burn away quite equally, but tapers down to a fine point where it comes into contact with the copper abutment A. After a while, however, this fine point breaks off and both carbons drop a small fraction of an inch until the solid part of C_1 again rests on the abutment. A faint click is heard when this takes place, but the light remains steady. The only slight disadvantage of this hot-wire type of lamp, we were informed, is that it takes some time (about 10 seconds) for the lamp to light up again when suddenly switched off and on. In many cases this is of no consequence, but to meet all requirements the firm are also making a lamp—otherwise identical with the one just described—in which an electromagnet takes the place of the hot wire. It has been found from experience that the copper abutment lasts two or three months. The light emitted is of a bright yellow color. Since the mechanism has been reduced to a minimum, and what there is of it takes up little room, the lamp is compact for its power, its overall height being 29½ ins. The hood is of sheet copper and is brightly polished in places, and the reflector is enameled in white.

Referring to Fig. 1, C_1 and C_2 represent the carbons, which are of a special quality, and not of the metal core variety. When the lamp is to be fed by continuous current, the carbons are of different thickness, and in the lamp we were shown at the works, the carbons were of a diameter of 8 mm. and 9 mm. respectively. It fitted with these carbons, the lamp, which consumes from 8 to 10 amperes, will burn from 10 to 12 hours before needing retrimming, but with carbons of 11 mm. and 13 mm. the hours of burning are increased to about 20. When used on an alternating-current circuit, carbons of the same thickness are used, of course. The carbons are 18 ins. long, and are clamped at the top by the carbon holders HH, which are fixed to, but insulated from, the cross slides SS. By this arrangement, if the carbon C_1 is allowed to drop, C_2 will travel down at the same rate. RR are of brass rod and serve to guide the cross slide. The carbons converge towards their lower ends as shown, and pass through two holes in the brass cup B. The carbons slide down together by gravity until the carbon C_1 rests against the abutment A, which is simply a bent copper bar secured by the screw D to the metal cup B. This cup, which is split to allow for expansion, is fastened to, but insulated from, the brass plate E. Its chief function is to protect the flame arc from draughts, but it also helps to reflect the light downwards. The copper piece A is provided for the carbon C_1 only, and the cross slides, the guiding rods and the holes in the cup B ensure that the second carbon C_2 moves in exact step with C_1. The magnetic flux to elongate the arc is created in the iron rods II, which are wound with bare copper wire. This wire is insulated from the iron rod by a layer of mica and other insulators. W is a stout wire of a nickel-iron alloy,

which also contains a little copper. When the lamp is not burning, the tension of the wire W keeps the striker F (whose fulcrum is at G) in the position shown, and the carbon C_2 is pressed against the carbon C_1 by the collar K, which is rigidly fixed to the striker. L is a thumb-screw, by means of which the tension of the hot wire W can be adjusted. In order to assist cooling, the middle portion of the hot wire is flattened out.

If the lamp now be switched into circuit, current will enter by one of the terminals TT, and, after flowing through the hot wire, the carbons and the blow magnets in series, will leave by the other terminal. The flexible connections (not shown in the drawing) between the various parts are protected in the customary manner by insulating beads. The hot wire heats up very quickly and elongates, and the striker is free to rotate in a counter-clockwise direction about G by gravity. At the same time the collar K moves towards the right, and in doing so draws the carbon C_2 away from C_1. In this way the arc is struck. When the current is switched off. the hot wire cools down and contracts; the striker is rotated in a clockwise direction against gravity and the carbons are again brought into contact with one another, ready for starting the arc. Although the whole length of the iron rods II, which constitute the cores of the blow magnets, is wound with copper wire, only a portion of the available turns is utilized. With alternating currents a larger number of turns is used than with continuous currents. The number of turns is easily regulated by connecting the flexible conductors to the copper helix (by means of clamps) at any point along the rod I. The glass globe M is held in place by the springy wire N and the cap O. The voltage across the arc is from 40 to 45 volts, and from 6 to 7 volts are lost in the carbons, hot wire and the copper helix which produces the magnetic flux.

A GERMAN MERCURY VAPOR LAMP

(From *Electrical Review*, March 23, 1906.)

The Quarz Lampen Gesellschaft is the title of a new company which has been formed in Berlin, and in which the Allgemeine Electricitäts Gesellschaft and the firm of W. C. Heraus, of Hanau, are interested. The company takes over the patents of Dr. Kuch, of the Hanau firm in question, relating to a mercury lamp which, according to the official statement, represents a material improvement over the already known mercury vapor lamp, from which it differs in being made of pure quartz and not glass. It is claimed that the advantage of the invention lies in the economy realized and in the possibility of manufacturing the lamps for all ordinary pressures up to 500 volts and of being able to place them everywhere singly in circuit; whilst at the same time the lamps require but little attention, as carbons are not used and the wearing out of the part to be replaced does not take place under 1,000 working hours. It is therefore submitted that the lamp will prove in many cases to be the substitute that has long been desired for arc lamps. As against this statement a technical correspondent of the Berlin *Tageblatt* remarks that the lamp is not new and that it was improved by the Hanau firm in continuation of the investigations which were begun by Dr. Arons in Berlin oven 10 years ago. The lamp, he declares, is not applicable as a source of light, but rather as a means of production for the so-called short wave action rays, that is, for chemical and physiological purposes. It gives a cold violet light; of more importance are the ultra-violet rays emitted by it, which are not seen but which are of considerable effect upon the human skin and upon the production of numerous chemical reactions. The rays proceed from the mercury vapor which is enclosed in a tube, and through which passes an electric current. The tube is made of quartz, or, as Herr Schott, of Jena, has shown, from special kinds of glass, as ordinary glass absorbs the most effective rays and would retain them in the lamp. The correspondent in conclusion states that it cannot yet be judged whether the lamp will find technical application on a large scale.

THE WOLFRAM LAMP

(From *Electrotecknik und Maschinenbau.*)

The General Electric Company, of Ujpest, Incandescent Lamp Department, reports the following:

Since the appearance of the Osmium lamp many experiments have been made to use different metals for lamp filaments.

Of the many metals examined for this purpose, wolfram, or tungsten, has proven the best adapted to the requirements of the economic production of incandescent lamps. The abundance of this metal and its high fusing point make it possible to produce an electric lamp which is both economical and durable.

The pronounced advantages of this metal in its pure state for electric lamps was first recognized by Dr. Alexander Just, and Franz Hanaman, engineer, who took out patents in 1903 for methods for producing filaments of pure wolfram. Since then a number of patents have been issued to the above named engineer in connection with the General Electric Company, of Ujpest, which, for the most part, have already been published.

The inventors hold that pure wolfram, free of carbon, is infusable. Experiments

which have been made in this direction have brought out the interesting fact that at the highest attainable temperature the metal evaporates without first passing through the liquid state. In this connection it has a similarity to carbon, with the difference only that the temperature of evaporating for wolfram is considerably higher than that of carbon.

The methods of Messrs. Just and Hanaman permit of the production of extremely fine, pure wolfram wire, by which it is possible to produce lamps for a tension of 110 v. and of comparatively small candle-power (32 c. p.). Equally fine wire has not heretofore been produced by the experiments made with osmium by the Pasta method.

A notable property of the Wolfram lamp is its high efficiency and long life. For example, the life of a Wolfram lamp of 110 v. and 40 Heffner candles, with an efficiency of 1 w. per candle, averages 1,500 hours, while the maximum life is considerably greater. Another characteristic of the lamp is the ratio of the useful life to that of its total life; there is no decrease in candle-power. The Wolfram lamp is not affected by higher voltage and therefore fluctuations of current in the supply wires does not affect the lamp. Pure aluminumoxyd has proven the most suitable material for attaching the Wolfram filaments, though mixtures of other oxides can also be used for this purpose.

The outer form of the Wolfram lamp is the same as the ordinary carbon filament lamp.

The Wolfram lamp is being put out by the General Electric Company, of Ujpest, who own the patents for Austria-Hungary, Russia, Belgium, Italy, Spain and Portugal. The German patents were owned by the Wolfram Company, Augsburg, but have been transferred to Geo. Ludecke & Company, Lechhausen.

A COMBINATION WELSBACH AND NERNST LAMP

(From *Electrotecknik und Maschinenbau.*)

Adolph Herz, of Vienna, has devised a combination of the Welsbach and Nernst lamps. Herz utilizes the principle that the higher the temperature of the incandescent body the higher will be the efficiency, as the visible part of the spectrum increases with temperature. The invention consists in passing an electric current of suitable strength and voltage through the incandescent body, which is already heated by the ordinary Bunsen flame, so that the body heated by gas receives an additional rise of temperature by the passing of the electric current, whereby the production of light will be increased accordingly.

INVERTED LAMPS FOR STREET LIGHTING

By W. R. Herring.

(From *Journal of Gas Lighting.*)

The Lighting Committee of the Edinburgh Corporation have resolved to recommend the City Council to convert the whole of the flat-flame burners that are not at present on the incandescent principle to this latter system, and have resolved to recommend the inverted burner for the purpose. About 6000 lamps remain for conversion out of a total of about 11,000 all told.

It may be interesting to note that we first experimented with the inverted incandescent burner, with a view to adapting it to street lighting, early in 1904, as the difficulty we had in Edinburgh in inducing the authorities to adopt the incandescent system of lighting was the fact that our street lamps had hitherto been rated at 2 cubic feet per hour; and the smallest type of incandescent burner that could then be recommended was 3 cubic feet per hour—thus adding considerably to the cost of public lighting as distinct from England, where the introduction of incandescent burners reduced the consumption.

The first lamp fitted in a public thoroughfare was set up on June 13, 1904, in New street. Later on some further lamps were fitted up, among others two at my house—one in the courtyard at the back, and one at the stable yard. These lamps have stood the test of time, with a very large admixture of storms; and they continue to be in every way satisfactory. The very marked superiority of both the appearance and effective illumination yielded by a lantern when fitted with the inverted burner, and the same lantern fitted with an upright burner consuming more gas, quickly convinced us that the future, so far as Edinburgh was concerned, lay in the adoption of this burner. Caution, however, being our natural characteristic, no great strides were made until further experience was gained by the lighting of some streets; and this has been proved during the past winter, with the result that the Lighting Committee are so satisfied as to recommend their universal adoption in the future.

The difficulty of adjusting a lamp governor with any type of incandescent burner to yield the proper rate of consumption with varying inlet pressures on the district, is a real one that has not yet perhaps received the attention it deserves. If an incandescent burner of any type is removed from a public lamp, and tested at various inlet pressures, it will be found that the consumption, instead of being constant, varies with the pressure on the governor inlet.

What originally led me to investigations which I have only very briefly outlined (and which I may say I have not even yet com-

pleted) was the trouble experienced with the deposit of carbon in the upper part of the inverted burner fitments. It was at first thought that the admixture of gas and air was improperly proportioned; but there appears to be little doubt that it originates from the low pressure during the midnight hours, which not only reduces the consumption of gas, but seems to entirely upset the injector effect of the gas current, and thus destroys the proportion of inflowing air, for we find by suspending a sheet of bibulous paper above the burner that no darkening takes place when the gas inlet pressure is at or about 20-10ths and upwards, but there are decided evidences of improper combustion below 15-10ths pressure.

PLAISSETTY SOFT MANTLES

(From *Journal of Gas Lighting.*)

Several ideas have been made public through the Patent Office for supplanting the ordinary form of finished mantles. The objects in view have been to obtain mantles or incandescing material which will not be subject to damage in transit, and to avoid the depreciating effects that investigators (more particularly Continental ones) have stated results from the subjecting of the mantles to the amount of collodionizing, after burning out the base fabric and hardening, necessary to admit of their safe transport. But after publication by the Patent Office, nothing more has been heard of these ideas. But that there is something in the incentives to these inventions is shown by the fact that Continental and London gas undertakings are doing their own burning-off for certain purposes.

In the *Journal* for March 6, we referred to the new flexible mantles which the Plaissetty Manufacturing Company have just brought out for inverted burners, with which mantles until they are placed on the burners the liberty may be taken of crushing with impunity.

These are some of the advantages that the Company claim for the mantles: "(1) The ash fabric of the mantle has not to be subjected to the same amount of treatment as previously by collodion; and the consequent weakening of the fabric is avoided. A mantle of three or four times the strength of the old mantle is obtained. The resistance to vibration is remarkable, and makes the mantle peculiarly suitable for the lighting of streets, railways, and factories. The householder will also get a mantle which will outlast three or four of the old mantles. (2) There is no risk of damage in packing or transit. The user can rely upon every mantle as it reaches him being sound. (3) In the case of export, the mantles cannot be damaged; every one will arrive in perfect condition. The bulk and weight of the packages will also be reduced to one-fifth of the old packages." The great thing is that nothing can happen to the mantles, between their manufacturing stage and the consumers' burner, to contribute to their wrecking. The sample mantles that we have received were purposely delivered in a crumpled and disordered state to prove this point. There may be some difficulty in getting private consumers to adopt mantles in this form, owing to the little additional trouble involved; but gas undertakings whose business includes the maintenance of street-lamps and private burners may find it to their advantage to test them.

INVERTED ACETYLENE BURNERS

(*Gas Engineers' Magazine,* April 10.)

At the recent International Acetylene Congress held at Liége, an inverted incandescent burner for acetylene was exhibited by a French firm. The makers claim that the burner gives a light equal to 50 French candle-power for a consumption of 12 liters, and one of 100 candle-power for 20 liters; and also that the average life-time of the mantles is 200 hours—with rigidly purified gas presumably. But they also state that the gas-pressure must be at least 30 centimeters, *i. e.,* 12 inches of water column, which, assuming the excellence of the burner in all other respects, seriously diminishes its utility.

SOME NOTES ON ACETYLENE

By F. H. Leeds, F.I.C.

(From *Journal of Gas Lighting.*)

Two matters have arisen in connection with the British acetylene industry during the past few months, which appear to have sufficient technical importance to deserve some little consideration. The first of these relates to the compression of a mixture of acetylene and oil gas, as brought into prominence by a Home Office Order issued last winter; the second is the question as to the advisability of allowing alloyed copper to come into contact with acetylene, which culminated when the last new rules of the London County Council about the employment of "dissolved acetylene" for cinematograph entertainments in theatres and the like, were published a few weeks ago.

ACETYLENE-OIL-GAS.

The original Home Office Order regulating the preparation and use of acetylene-oil-gas bears the date of March 28, 1898; and its essential provisions are that a mixture containing not more than 20 per cent. by volume of acetylene may be compressed to a limit not exceeding 150 lbs. per square inch. To be precise and worthy of a legal enactment of this nature, the temperature at which the pressure must not exceed the prescribed point ought to be mentioned; but this has not been attended to.

In order to consider the relative propriety of these directions, some of the physicochemical properties of acetylene have to be studied. Being an endothermic compound, there is a kind of critical pressure at which acetylene stored in the absence of air loses its natural degree of stability. Below that pressure, a spark produced by friction or electricity, or a severe shock applied to the interior of the vessel holding it, produces no more than a purely local dissociation into its elements; the extent of the decomposition being so circumscribed as to be of no practical importance whatever. Above the critical pressure named, however, a spark, shock, or a suitable heating of the vessel, causes the whole bulk of gas present to dissociate violently; and the decomposition proceeds with the accelerating velocity which characterizes an explosion. According to the experiments of Berthelot and of Dupré in this country, the so-called critical pressure lies at a point which, at ordinary temperatures, is sensibly that of two atmospheres absolute. Hence the maximum effective pressure set up during the preparation or use of neat acetylene, is always regulated by law or otherwise to some figure appreciably less than that of one atmosphere; the only exception being when the gas is compressed by its manufacturer, without loss of time, into acetone held within the interstices of an appropriate porous material ("dissolved acetylene").

Thus it may be said that the maximum degree to which acetylene when uncontaminated with air or other impurities, and not diluted with any other gas, may be safely compressed is one lying somewhat lower than a "partial pressure" of two atmospheres absolute. It follows, therefore, that if the acetylene is first diluted with some gas which is wholly indifferent to it, and neither increasing nor diminishing the natural tendency of the acetylene to dissociate —some gas which is (obviously) stable of itself at the pressure contemplated—the mixture of acetylene with the other gas may be safely raised to a pressure, at ordinary temperatures, at which the acetylene in the mixture stands just below a partial pressure of two atmospheres absolute. It is needless to say that the acetylene in a mixture containing 20 per cent. by volume of that constituent exists at a partial pressure of two atmospheres when the whole mixture is raised to a pressure equal to 150 lbs. per square inch. Now, it is highly probable that no such ideally indifferent diluent gas exists, but that of the gas with which the acetylene is diluted does not increase the tendency of the latter to dissociate, it diminishes the tendency. Therefore, if a mixture of acetylene with a suitably sluggish or indifferent gas is prepared, the mixture is not likely to be capable of dissociation (even so far as the acetylene in it is concerned) under the influence of a spark or shock until the whole is so highly compressed that the acetylene stands at a partial pressure appreciably exceeding that of two atmospheres absolute.

Atkins acetylene apparently without any chemical purification, has been examined by a Westminster analyst, and found to contain 0.082 milligramme of phosphorus per litre, 0.010 milligramme of sulphur, and 0.366 milligramme of ammonia. These figures represent a sufficient degree of purity for all practical purposes—except the ammonia perhaps, and indicate a gas that would in all probability pass a properly applied Keppeler test-paper. If such a degree of purity were to be constantly maintained, the acetylene would behave well under an incandescent mantle, always provided that no dust were carried forward from the agitating drum. The report asserts that the phosphorus compounds resulting from the decomposition of phosphides in the carbide are retained by the sodium in the form of "sodic phosphite"—a statement of which I should like some confirmation. The purity of any particular sample of acetylene depends not only on the method of generating it, and on the method (if any) of chemical purification, but manifestly on the quality of the carbide decomposed.

Everybody concerned in the acetylene industry might be supposed to have a reasonably clear notion as to the risk involved in allowing acetylene to come into contact with copper itself. When the gas is warm, moist, and charged in the natural way with impurities—especially ammonia—it is liable to react with unalloyed copper, yielding a body known as copper acetylide, which is sharply explosive when dry. Conclusive evidence that a similar reaction cannot take place when the acetylene is pure has not yet been offered, although there is much probability in the assumption that a reaction between metallic copper and pure acetylene, with copper acetylide as the product, is somewhat unlikely to occur. Hence the employment of unalloyed copper in the construction of acetylene plant is prohibited by law, practically forbidden by fire insurance officials, or condemned by the different Acetylene Associations—as the case may be. The new Government code of rules which came into force in Austria in February, 1905, says "parts that come into contact with carbide or acetylene must not be constructed of metals (especially copper) which form explosive compounds with the gas. Copper alloys, such as brass, bronze, and the like, may be used for cocks, valves, screw connections and similar parts; and these must always be kept clean." In the analogous general code which came into operation in most parts of Germany at the beginning of last October or soon afterwards, the corresponding rule reads "Copper must not be used in the construction of

any part of the apparatus or service-pipes. The employment of brass is permissible." There is a virtually identical rule in the suggestive code of our Acetylene Association. The rules of the German Association specify that apparatus shall only be constructed of wrought or cast iron; that unions, cocks, and valves shall not be made of copper; but that the use of brass and bronze is permitted. Thus the general trend of expert opinion is that there is no objection to having allowed copper in or about acetylene plant.

All that need be pointed out is the absence of any real necessity for prohibiting the employment of alloyed copper in ordinary forms of acetylene apparatus, while emphasizing the desirability of avoiding the use of that metal in the unalloyed state. Numberless cylinders of dissolved acetylene in which the accessories—such as the reducing valve, high and low pressure gauges, the stop valve, unions, and connectors—are composed of some alloy like gun-metal have been in use for several years, and are so still, in France, the United States, this country, and Austria; and no accident has yet occurred in connection with them. The writer has experimented with one of these cylinders for months, carrying out numerous photometric observations upon the behavior of incandescent acetylene burners with the aid of dissolved acetylene (on the results of which investigation he hopes to be able to report shortly); and on no single occasion has he experienced the least accident or mishap, or found the cylinder to fail in its delivery of gas with the utmost smoothness desirable.

AN INGENIOUS FRAUD

(From *Electricity,* April 20, 1906.)

An esteemed contemporary, the *Hardwareman,* has recently exposed, in its columns, a peculiarly ingenious form of electric light fraud, which is being worked in various parts of the country, and from its nature is calculated to entrap the unwary electric light consumer, or even the wiring contractor if his electrical knowledge be little and therefore dangerous. As it may be the means of saving some of my readers, or, at all events, their clients, from being victimized, I give the *modus operandi* herewith. There is a London firm of so-called electrical engineers, who are approaching various electric light consumers throughout the country with an offer to reduce their quarterly accounts for electrical energy, and, what is more, to do it on the instalment plan, "no saving, no payment." To this end they offer to supply the consumer, free of charge, with incandescent lamps for any period of not less than twelve months, taking payment for same from the consumer, monthly, in sums to be paid on the cash value of current saved by the lamps as compared with the corresponding period of the previous year.

Should the consumer not desire an easy system of payment, but proffer to buy the lamps outright, the firm are prepared to submit any number of their lamps for testing, on the consumer's own meter, to prove what saving in current consumption is effected over the same number of lamps previously used. A condition of this test is that the consumer shall use new lamps in competition with the current-saving variety, in order to make the test apparently more fair. So far as current consumption goes, the offer is perfectly *bonâ fide;* the new lamps supplied by this enterprising firm do show a saving as compared with the ordinary 16-c. p. incandescents so largely used for the electric lighting of shops, hotels, restaurants, private houses, etc., but the trick consists in the substitution of a foreign-made 8-c. p. lamp, *marked 16-c. p.*, for the genuine 16-c. p. lamps already in use. With the aid of an ammeter these traveling salesmen readily convince the layman of an acknowledged electrical fact —viz., that an 8-c. p. lamp consumes less current than one of twice the candle-power, and the result is usually an order for the new lamps, which show a saving of about 33 per cent. on the quarterly accounts of the supply company. The essence of the fraud consists, of course, in showing off a new 8-c. p. lamp against an old one of 16-c. p. The one takes less current, and is, apparently, more brilliant, hence the trapping of the unwary.

WHY AMERICAN LAMPS SELL IN ENGLAND

(Editorial, *Electrical Review.*)

Why is it that some manufacturers insist, in season and out of season, on the better conditions for manufacture that obtain in the United States and the Continent than in Great Britain? Ten or twenty years ago, before this was the fashion, the British manufacturer, when he spoke in public, took the line that his goods were the best, although some foreigner might possibly be able to sell goods of inferior quality to his at a cheaper rate. Now he loses no opportunity to insist on the conditions which, he says, enable the foreigner to make the same class of goods as his own at a lower price. He is, in fact, too apt to forget that he is a business man, and to become a politician.

WASTE IN INCANDESCENT ELECTRIC LIGHTING AND SOME SUGGESTED REMEDIES

(From *Electrician*, March 16, 1906.)

We report this week at considerable length the discussion on Mr. George Wilkinson's proposals for checking the wasteful use of old and inefficient lamps by consumers, and we do not doubt that these expressions of opinion from different quarters will be found valuable by the supply station engineers. The lamp makers' point of view was ably expressed by Mr. Wilson, but he made too much of the disadvantages under which he says lamp makers in this country suffer on account of the absence of "grading" in supply station voltages. Perhaps the lamp makers have not been consulted as to this grading, but we venture to suggest that the variety in declared pressures in this country should be quite sufficient to afford a market for the "outfalls" in 220-volt lamp manufacture.

To return to the question of the grading of the various pressures and the number of lamp pressure: A buyer of lamps, after reading Mr. Wilson's remarks, will naturally say, if the American lamp maker can make his lamps cheaper, owing to this process of grading, we shall get better value for our money in America—either better lamps at the same price, or the same quality lamps as in England, but at a lower price. He will therefore buy in America. Fortunately there is little foundation for Mr. Wilson's complaint on this score, although his figures and data on other points have a praictical value.

Mr. Wilson had twice had the opportunity of visiting the United States, principally with regard to the lamp business, and it could not be denied that the lamps supplied in America were far more closely graded than the lamps supplied in this country owing to the advantageous conditions under which they worked. The central stations in America were closely allied to, and worked hand in hand with, the lamp manufacturer, and if it was found in their lamp works that they had a percentage of outfalls for which there was no demand, in the next central station which was put down the voltage was graded to suit that particular line. There should, he thought, be no difficulty in arranging that a standard voltage should be set up, and that, say, 60 per cent. of the stations be run at this standard voltage and the other 40 per cent. be graded below and above in steps of, say, 4 or 5 volts.

Mr. Emmott said that exhibitions, permanent showrooms and advice on gas-consuming appliances were at the service of the customer of a gas undertaking; and he strongly advocated something of this nature in electricity undertakings. He had had a large number of tests made somewhat on the lines indicated by Mr. Wilkinson for some time and generally agreed with his results, although he had few so bad as the worst recorded in the paper; they were in his experience, the exception and not the rule. Consumers required educating; for instance, many good lamps lost 15 per cent. of their illuminating power simply through an accumulation of dust.

Mr. Woodhouse said that they must make the consumer their study. Improvements in the station were not so necessary as in consumers' installations; they must remember, in fact, that they were selling light, not current. He agreed with Mr. Wilkinson that the wiring contractor was a valuable canvasser and should be encouraged. Mr. Wilkinson's system of ensuring good lamps to the consumers was excellent. There were other ways of doing this; one system which worked successfully was to change all the consumers' lamps every six months and supply new ones. Those taken out were tested for wattage and candle-power; those that did not come within certain limits were destroyed, and the others were returned to stock ready to be sent out aagin. The cost of doing this could be included in the price per unit charged for current. On the subject of lamp testing he would like to ask the lamp-makers whether conclusions drawn from ageing and wattage tests, at pressures above the normal, could be depended on. Mr. Wilkinson suggested ageing lamps at 50 per cent. above their rated pressure, and if the tests made after such accelerated ageing could be relied on much time would be saved.

Mr. A. S. Blackman, whilst agreeing with the author to a certain extent, certainly thought that he was advocating a most cumbersome method of getting over the difficulties. As would be generally known, his predecessor (Mr. A. H. Gibbings) initiated a system of supplying free lamps in Bradford, and after two years' experience in working the system he (the speaker) certainly thought it was one of the very best things that had been done in the way of looking after the consumers' end of the problem. They had been distributing something like 14,000 lamps per annum. and the cost of supplying them amounted to less than 3 per cent. of the consumer's bill. This could be looked upon as a discount of 3 per cent., and it is rather interesting to note that previous to the free lamp scheme, the consumer had a discount of 2½ per cent. allowed for prompt payment, but the free lamp system was found to ensure this very much better than the giving of discount, from which it could be inferred that the consumer appreciated this very much more than a corresponding reduction in his account. They had found from experience that a man felt it a good deal more when he lost his lamps than his discount.

Miscellaneous News

AUBURN, N. Y.—Gov. Higgins has vetoed bills fixing the price of gas in Auburn, Seneca Falls, and Watertown at one dollar per thousand feet.

ALBANY, N. Y.—A corporation has been chartered under the name of the Interstate Gas Light Co., for the purpose of manufacturing gas-making machines, and installing private gas plants. Headquarters have been established at 34 Lodge street. The company is looking for a factory in which to carry on the manufacture. The capital stock is $75,000.

BOSTON, MASS.—The Rising Sun Street Lighting Co. has renewed its contract with the city for the lighting of streets with gas lamps until January 1st next.

BUFFALO, N. Y.—After a considerable agitation by the Mayor, and those favoring municipal ownership, the question has been settled for the next five years by the Buffalo General Electric Company reducing the cost of the street arc lamps from $75 to $56, and making satisfactory reductions to private customers. The arrangement appears to be satisfactory to all parties concerned.

CHICAGO, ILL.—An ordinance agreed upon by the Council Committee on Gas, Oil, and Electric Light, permits the Edison and Commonwealth companies to unite, but does not permit of their taking in companies outside of the city. The price of arc lamps to the city is to be $75 per year. The price of current to consumers is on the following basis: for the next two years, maximum 15 cents per kw. hour; for the succeeding three years, 13 cents; to consumers using more than thirty kw. hours per month, 10 cents per kw. hour the first year, 9 cents the second, 8 cents the third, and 7 cents the fourth and fifth years; discount of 1 cent is to be allowed for prompt payment of bills. The contract with the city is to run for five years, beginning June 15th.

GREAT FALLS, MONT.—The city has voted to grant a franchise to Henry W. Mahaney, of Spokane, to erect and maintain a plant for the manufacture and distribution of illuminating and fuel gas and by-products. The franchise carries a guarantee to pay 2 per cent. of the gross receipts into the city treasury.

LOUISVILLE, KY.—On account of the rejection of the Atherton-Jones electric franchise ordinance by the board of aldermen, charges are made that illegitimate means were used to influence the vote. An investigation is on by an aldermanic committee.

NEW YORK CITY.—The Consolidated Gas Company are testing in the courts the constitutionality of the bill recently passed reducing the price of gas to 80 cents per 1,000. By an order of the court the consumers must continue to pay the $1.00 rate, but will receive a rebate in case the bill is sustained. The Brooklyn Union Gas Co. will charge the 80-cent rate, and reserve the right to collect the difference in case the bill is not sustained.

PHILADELPHIA, PA.—As a result of efforts on the part of the mayor and citizens to secure competition in electric lighting, the Commonwealth Electrical Co. have agreed to accept a 50-year limit to their franchise. This offer is being opposed in the hope that a competing company may be formed.

PITTSBURG, PA.—The Pennsylvania Railroad has been experimenting during the past year with a new method of lighting its passenger coaches by electricty. Such satisfactory results have been obtained that all the new passenger equipment to be built for the lines west of Pittsburg this year will have the improved system, which consists in using five 50-c.p. incandescent lamps, fitted with Holophane reflectors, for each car, instead of five clusters of eight 4-c.p. lamps. It is figured that with the reflectors the illumination will be increased to 85 c.p. on the surface of a newspaper held by a passenger.

PITTSBURG, PA. — The Allegheny County Light Co. will make another year's contract with the city of Pittsburg for furnishing lights for the streets. The company promises a cheaper rate than heretofore.

SYRACUSE, N. Y.—Probably the most searching public investigation of the operation of electric light and gas plants that has ever taken place has been brought to a close in this city by the State Commission of Gas and Electricity. Numerous experts were called on both sides and all possible information made public. The testimony will cover 500 pages. The interest aroused in this investigation has created a general crusade in the principal cities of the United States for investigation, with the expectation of getting cheaper rates and better service.

TROY, N. Y.—Mr. Gaus has requested the State Commission of Gas and Electricity to investigate the Albany Electrical Illuminating Co. and fix a maximum price which the company may charge for its current.

Judge Andrew Hamilton, of the "yellow dog" insurance fund notoriety, is attacking the legal status of the commission.

From Photo by Marceau taken under the Moore Vacuum Tube Light.
DANIEL McFARLAN MOORE.

The Illuminating Engineer

Vol. I. JUNE, 1906 No. 4

Practical Problems in Illuminating Engineering

By Arthur A. Ernst.

III.—THE LIGHTING OF A SECTION OF THE MARSHALL FIELD STORE, CHICAGO.

The difficulties which the illuminating engineer most frequently has to encounter in practical work are vagueness in requirements, and a lack of scientific and accurate methods of checking the results. The owner of a building usually has a general though indefinite idea of what he expects in the way of results, which indefiniteness is further increased when imparting his ideas to the engineer. Gathering what information he can from these more or less indefinite statements, the engineer is forced to depend largely upon his own judgment as to the illumination required for the purposes in hand. In the case treated in this article the reverse of these conditions was presented. The specifications were exact and exacting, and the results demanded were such as could only be secured by a careful study of the problem and a resort to the most efficient devices obtainable. The conditions were purposely made very specific, since the installation was intended as a demonstration in one part of the building, the results to furnish a basis for laying out the illumination in the remainder of the building.

The following were the conditions as specified by the electrical engineer of the building:

A uniform horizontal intensitv of 3.75 foot-candles on the counters;

Current consumption not to exceed 800 watts per ceiling panel;

Fixtures not to exceed ten dollars per ceiling panel;

Maintenance charge not to exceed .4c. per k. w. hr.

Light to be of such a color as to properly display the various goods.

No arc lamps to be used.

The following were the architectural conditions:

Ceiling panels, 21 x 22 feet;

Ceiling height, 15 feet;

Pillars 30 inches in diameter;

Height of the counters, 32 inches;

Counters, shelving, etc., mahogany finish;

Floors covered with dark carpets;

Voltage available, 113.

Seven outlets were provided in each panel as shown in the diagram Fig. 1. This arrangement admitted of the use of 1, 2, 4, 5, 6, or 7 lamps or fixtures symmetrically placed thus giving ample facilities for varying the position and number of units. The results were to be determined by measurements throughout; that is, the illumination was to be measured by an illuminometer, the current consumption recorded in the usual manner, and the maintenance charges calculated by the

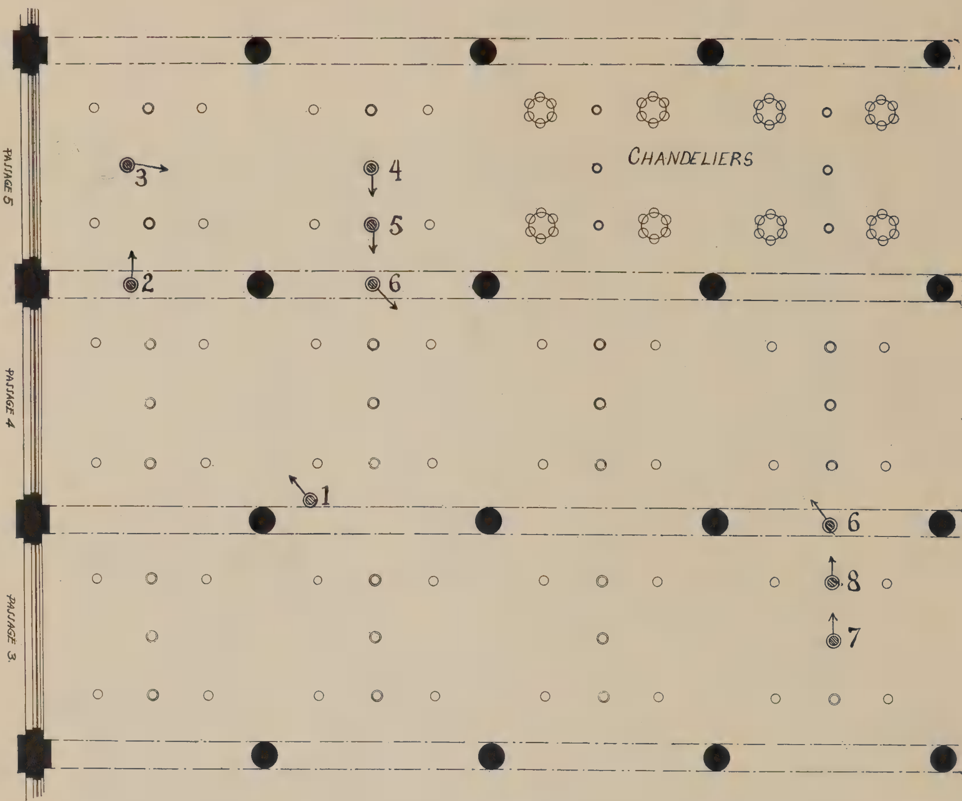


FIG. 1.—PLAN OF A PORTION OF THE FLOOR, SHOWING POSITION OF OUTLETS, AND LOCATION OF ILLUMINOMETER TESTS.

record of a sufficiently long period of use.

As the client in this case was a manufacturer, the illuminating engineer was further restricted to the use of a particular make of lamp and accessory.

Selecting the arrangement of five units as the one best suited to produce uniformity, calculations were made on the basis of "G. E. M." lamps fitted with Holophane reflectors. In order to secure the best possible results a special form of reflector was used, illustrated in Fig. 3. The distribution curves of these reflectors with 125 watt (50 c.p.) and 187 watt (75 c.p.) lamps are shown in Fig. 2.

Five lamps were placed in each panel, the four at the corners of the square of 50 c.p., and the one in the center 75 c.p. The horizontal intensity at the counter level in a line between the center of adjacent panels

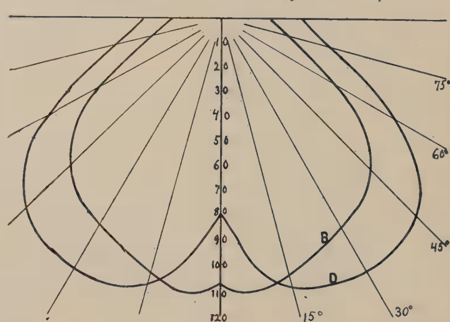


FIG. 2.—CURVE B, DISTRIBUTION OF 125-WATT LAMP AND REFLECTOR. CURVE D, 187-WATT LAMP AND REFLECTOR.

was then calculated, and found to be as shown in Fig. 4.

It will be seen that the illumination falls very slightly below the specified

FIG. 3.—REFLECTOR AND HOLDER FOR 50 AND 75 C.P. LAMPS.

amount of 3.75 foot-candles; but as no allowance has been made in these calculations for reflection from the ceiling and other objects, nor from the light from any other lamps except the two adjacent posts, it was believed that the actual illumination secured would be above the specified intensity.

As to fixture cost: by using the simplest arrangement for suspending the lamp and reflector, as shown in the illustration, Fig. 3, this item could be brought within the required amount.

In current consumption, a great gain was made over the maximum allowed by the specification, the amount used in this case being 687 watts per panel in place of 800.

In maintenance charge, however, the limit will doubtless be exceeded considerably by the use of these lamps. This excess, however, will be much more than offset by the reduction in current consumption. The installation was made on these lines and the results checked by the use of an illuminometer. The results are as follows:

Station.	Foot-Candles.
1	8.8
2	8.0
3	7.2
4	8.8
5	7.5
6	8.1
7	10.6
8	10.4
9	11.4

As may be imagined, these results of actual measurements were both satisfactory and unsatisfactory to the engineer; they were satisfactory in that the intensity of illumination was far above the requirements, and presumably, therefore, very pleasing to the owner; but unsatisfactory in that they were so widely at variance with the results obtained by calculation. It is to be noted, however, that in the calculations no account was taken of reflection, which proved to be a high factor, or of additional light from distant lamps. This doubtless accounts for a considerable portion of the discrepancy.

In the general effect produced as to color, distribution, diffusion, etc., the heads of the various departments expressed themselves as highly pleased. The item of maintenance cost of course cannot be determined until the installation has been running for sixty days or longer.

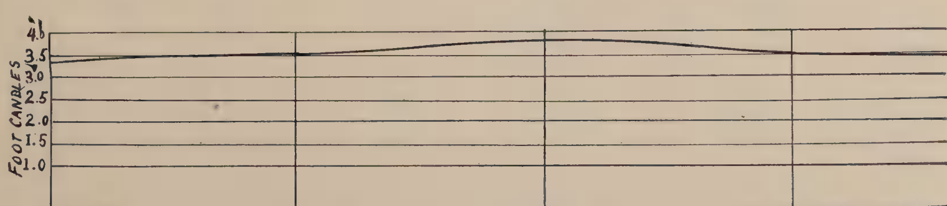


FIG. 4.—CURVE OF HORIZONTAL INTENSITY FROM CALCULATIONS.

PHOTOGRAPH OF SECTION OF STORE TAKEN BY DAYLIGHT TO SHOW LOCATION OF LAMPS.

A test made on the first floor, where four six-light chandeliers are used in each panel (see Fig. 1), with 16 c.p. lamps surrounded by the ordinary ground glass shade, rough inside, showed an average of four foot-candles, with a current consumption of about 875 watts. This case was exceptional, however, since a number of chandeliers in other localities on that floor had 8 c.p. lamps, with a corresponding decrease in illumination.

On the whole, the problem is interesting as indicating to what degree of accuracy illuminating specifications can be drawn, and the limits of error within which it may reasonably be expected to obtain results.

IV.—THE LIGHTING OF A PORTION OF MICHIGAN AVENUE, CHICAGO.

This installation is a fair example of a number of recent attempts to secure a more artistic form of street illumination than is commonly provided by the use of the arc lamp. The lamp posts and accessories have been designed with a view to securing a dignified and ornamental appearance. In the original installation clusters of lamps were used in each globe, but recently these were changed on a number of the posts to "G. E. M." high efficiency units. The results of illuminometer measurements made at several points about lamp posts of each kind may be of interest. The following data will give an idea of general conditions:

Distance between lamp posts on the same side of the street	82 to 90 feet.
Width of street	55 "
Height of center globe above sidewalk	13 "
Number of globes to each post	7
Diameter of center globe	12 inches.
Diameter of surrounding globes	6 "
Globes clear glass frosted on the inside.	
Spread of arms on post	24 to 32 inches.
Small globes contain	two 16 c.p. lamps.
12-inch globes contain	five 16 c.p. "
On the posts fitted with "G.E.M." lamps the center globe contains,	one 187 watt (75 c.p.) lamp.
Six-inch globes contain each	one 125 watt (50 c.p.) lamp.

Illuminometer readings taken with the instrument on the sidewalk, which represents a plane about one foot above the street at positions 10 feet apart between two posts equipped with "G. E. M." lamps, gave the following results:

Directly underneath	.4 foot-candle.
5 feet from posts	.8 " "
15 " " "	.4 " "
25 " " "	.2 " "
35 " " "	.1 " "
45 " " "	.09 " "

Between posts fitted with the clusters the following results were obtained:

Directly underneath	.8 foot-candle.
5 feet from posts	.6 " "
15 " " "	.4 " "
25 " " "	.2 " "
35 " " "	.1 " "
45 " " "	.09 " "

In the middle of the street the intensity measured .2 foot-candle. The minimum illumination is, therefore, practically .1 foot-candle. This intensity enables the time to be read on the face of a watch with ease, and the print of an ordinary card also. It will be seen that the illumination of the two arrangements of lamps is practically the same.

The lamp posts fitted with "G. E. M." lamps were consuming 937 watts, and those fitted with the clusters, assuming 3.5 watt lamps to be used, 952 watts. The advantage of the higher efficiency lamps in this case should have shown an increased illumination, as the wattage consumption is practically equal. The absorption by globes and interference of the light of one globe with another apparently reduces the entire illumination to such an extent as to render this increase imperceptible.

The quantity of current used is nearly sufficient to maintain two enclosed arc lamps, which, even though fitted with diffusing globes, would give a considerably greater intensity of illumination than the incandescent lamp. Owing to the fact that an arc lamp is always suspended from an overhead fixture, and also that the larger part of the light emitted is at angles which readily reaches the pavement, practically all of the light transmitted by the globe is effective in producing illumination; whereas with the incandescent lamps as installed considerably over one-half of the light generated is entirely lost by being thrown into space above the pavement, and a very considerable amount of the remaining portion is lost by interference from the cluster of the globes, supporting arms of the lamp posts, and the frosted glass. Thus, while the arc lamp as commonly used is at its best in similar installations, the incandescent lamp is at its worst. It is, therefore, unlikely that incandescent street lighting will make much progress against arc lighting except where the decorative effect is paramount, until more efficient devices are constructed.

PHOTOGRAPH OF ART STORE TAKEN BY MOORE LIGHT.

The Moore "Vacuum Tube" Light

"Three-tenths of one per cent. of the energy consumed is converted into light." The first time that I saw this statement it struck me like a blow over the solar plexus. Here, said I to myself, is the way pointing toward the richest undiscovered territory of science in existence at the present time. I will henceforth devote my energies to an exploration of this field. This was over twelve years ago, and it is only within the last six months that I have secured results which may be considered a practical opening up of this undiscovered country in which I have been prospecting." It was thus that Mr. D. McFarlan Moore prefaced his remarks concerning the system of lighting which has been known by his name for the past decade.

Mr. Moore is a typical example of the scientific investigator. So impressed is he with the importance of the work in hand, and so confident of ultimate success, and so enthusiastic in pursuit of the coveted knowledge, that the most stubborn "doubting Thomas" cannot escape being infected by his buoyancy. His excess of enthusiasm has perhaps in some cases been a detriment, for it is easy for the uninitiated to mistake a sincere interest and enthusiasm for mere vagaries of an inventor or vaporings of a charlatan. With such natures the wish is often father to the thought, and they are thus led to promise results before they are able to accomplish them; and to the general public "hope deferred maketh the heart sick." Many will recollect that Edison announced the successful solution of incandescent electric lighting several years before he was able to actually produce the results, which resulted in more or less public ridicule and censure; and the

same has been true to a greater or less extent of the previous work of Moore. There is every evidence at the present time, however, that he has accomplished practical commercial results which are of the highest importance in the field of light production.

The nature of the Moore light is rather inaccurately expressed in the appelation of "Vacuum Tube Lighting." Strictly speaking, a vacuum is a space void of all ponderable matter, and the tubes which are used in the Moore light contain small quantities of matter in the gaseous state. The basic principle of the Moore light is defined in the most elementary books on electricity, wherein it is stated that air of the ordinary density, that is, under the ordinary atmospheric pressure, is a non-conductor of electric currents, but if the density be reduced to a sufficient degree, the resistance is reduced to such an extent that it may be considered a conductor. The passage of an electric current through a rarefied gas causes it to glow. The old familiar apparatus known as the Crookes' tube exemplifies these facts.

The Moore light of the present time is simply a glass tube of convenient diameter and of any desired length, having electrical conductors hermetically sealed into the opposite ends and the air within exhausted to such a degree as to bring it to the point of conductivity for electric currents of available pressure. The passage of the current raises the rarefied gases to a state of incandescence. Any one wishing to produce a Moore light on a small scale can do so by finding a discarded incandescent electric lamp from which the air has been improperly exhausted, and passing the discharge from a spark coil through it. The beautiful natural phenomenon commonly known as "Northern Lights" is supposed to be due to the same conditions as exist in the Moore light; and so, following the rhetorical expressions so often used in describing Franklin's classical experiments with kite and keys, in which he is said to have "harnessed the lightning," we might say that Moore has bottled the aurora borealis, an expression which, if less dignified, is much more accurate, scientifically speaking.

But the layman will naturally ask, "why should a matter so simple and so well known have remained so long unused?" This question invariably arises on the perfection of every discovery of importance. Only those who have had experience realize that the difficulty of perfecting a discovery is directly proportional to its simplicity. Any bungler can devise complications, but it takes a genius to replace them with simplicity. What is simpler than the incandescent electric lamp? and yet its practical production was justly held as a triumph of inventive genius. So with the vacuum tube light; looking at it in its present degree of perfection, its absolute simplicity is its most astonishing feature. Nevertheless, it is the result of more than ten years of continuous and well directed effort.

Without reviewing in detail the various steps in the evolution of this new light-source, we may consider it in its present commercial form. As before stated, it consists essentially of a glass tube having electrodes at opposite ends and containing ordinary air highly rarefied. With the continuous passage of an electric current, however, the air becomes gradually more rarefied on account of electrolitic action of the gases in contact with the electrodes. This increases the rarefaction, and as is well known, beyond a certain density any further rarefaction increases the electrical resistance. Provision must, therefore, be made for maintaining this resistance at a practically uniform point, in other words, of admitting air to the tube in extremely minute quantities and at regular intervals so as to maintain a constant pressure of the enclosed air. This is really the crux of the whole matter. To accomplish this Mr. Moore has invented a check valve which is practically frictionless and indestructible and so delicate in operation as to be sensitive to

a difference in pressure of one forty-thousandth of an atmosphere. This statement sounds like a perpetual motion inventor's formula, but a glance at the mechanism shown in the diagram will at once convince the reader that these seemingly impossible conditions have been accomplished.

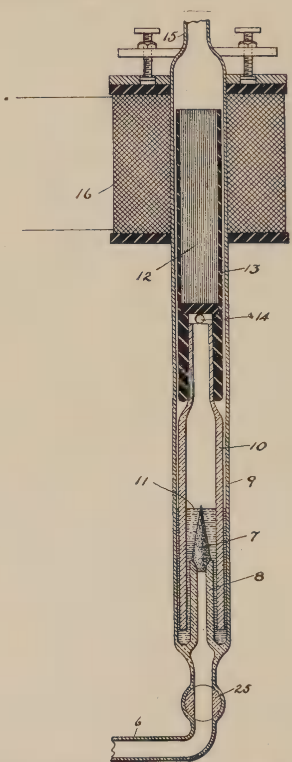


FIG. I.—VACUUM REGULATOR OF MOORE LIGHT.

The regulating apparatus is connected at *6* with the vacum tube; *7* is a cone of carbon or other slightly porous material tightly joined to the tube *8*. Around this is an annular space filled with mercury, *11*. Into this annular space is dropped a glass tube *10*. By properly adjusting the quantity of mercury, the tube or displacer *10* will cause the mercury to completely cover the cone or leave the tip bare, according as it is raised or lowered in the mercury. If the tip is left bare a minute quantity of air will filter through the porous carbon and so enter the light tube, but once the cone is covered with mercury again the air is perfectly excluded. The only friction in the operation, therefore, is that of the glass tube in contact with the liquid mercury, which may be considered nil. The regulation is effected by connecting the displacer *10* to the core of a solenoid, the solenoid being connected in series, or in any other effective way with the current used to generate light, and so arranged that any decrease in resistance will cause a lowering of the mercury and a consequent laying bare of the carbon cone, thus admitting air to the tube which will restore again the normal resistance. The slight movement required to perform this regulation is the only movement in the entire apparatus. Mr. Moore's claim that the apparatus is practically indestructible is therefore within the bounds of truth. The only other apparatus required is a small transformer to produce a sufficiently high electromotive force to pass the current through the necessary length of tube. This may be installed at any convenient point, but is usually placed at the ends of the glass tubes.

In installing the lighting system, the tubes, which come in lengths of six to eight feet, must be hermetically joined, and exhausted to the proper degree, an operation which, though simple in the stating, is far from easy of accomplishment by ordinary means; and one of the problems to be solved was the construction of necessary apparatus for performing these operations. This has been accomplished to a very satisfactory degree.

For all ordinary purposes of illumination common air produces a light of acceptable color, being of a warm and mellow hue with a slightly rose-colored tint, the predominant color being that of the spectrum of incandescent nitrogen. If light of sunlight color is essential it is readily produced by the introduction of small quantities of other permanent gases which will supply the additional rays. Such light is, however, less efficient for the very simple reason that the eye is less sensitive to these additional rays and consequently they must be added in com-

FIG. 2.—PHOTOGRAPH OF STORE TAKEN BY LIGHT OF ELECTRIC LAMPS.

paratively greater quantity to produce the visual effect.

One of the chief advantages of the Moore light is its low intrinsic brilliancy. In this respect it stands alone among modern light-sources, excepting only the mercury arc, whose color practically excludes it from general use. The entire tendency for the past ten years has been toward the production of light-sources of higher intrinsic brilliancy, the electric arc being the limit thus far. No better proof of the low intrinsic brilliancy and consequent freedom from glare of the Moore light can be given than the effects produced upon the ordinary photographic plate. The illustration Fig. 2, is from a photograph taken by the light of a number of incandescent electric lamps. The familiar halation is the exact photographic counterpart of the glare produced when such lights are seen by the eye. Fig. 3 is the same room taken from the opposite end by the light emitted by the Moore vacuum tubes; the practically total absence of all halation (glare), is readily apparent, while the remarkable clearness of detail of the entire picture is an equally exact indication of the distinctness of the visual impression which would be produced. Without question this is the closest approximation to sunshine admitted through a skylight that has ever been produced.

The illustration given on the front cover is exceedingly interesting as a study in evolution. Through the center of the room there are still in place the old-fashioned gas chandeliers, using a number of flat flames arranged around the ring under the opal reflector. This device may be considered the highest degree of perfection of gas flame illumination. On either side are arc lamps, which fairly represent the next step in the evolutionary process. With these an abundance of light would be produced, but glaring and unsteady. Last, the vacuum tube light, reproducing the exact visual effect of daylight, perfectly steady, and without perceptible glare.

FIG. 3.—PHOTOGRAPH OF STORE SHOWN IN FIG. 2, TAKEN FROM THE OPPOSITE END, BY LIGHT OF MOORE TUBES.

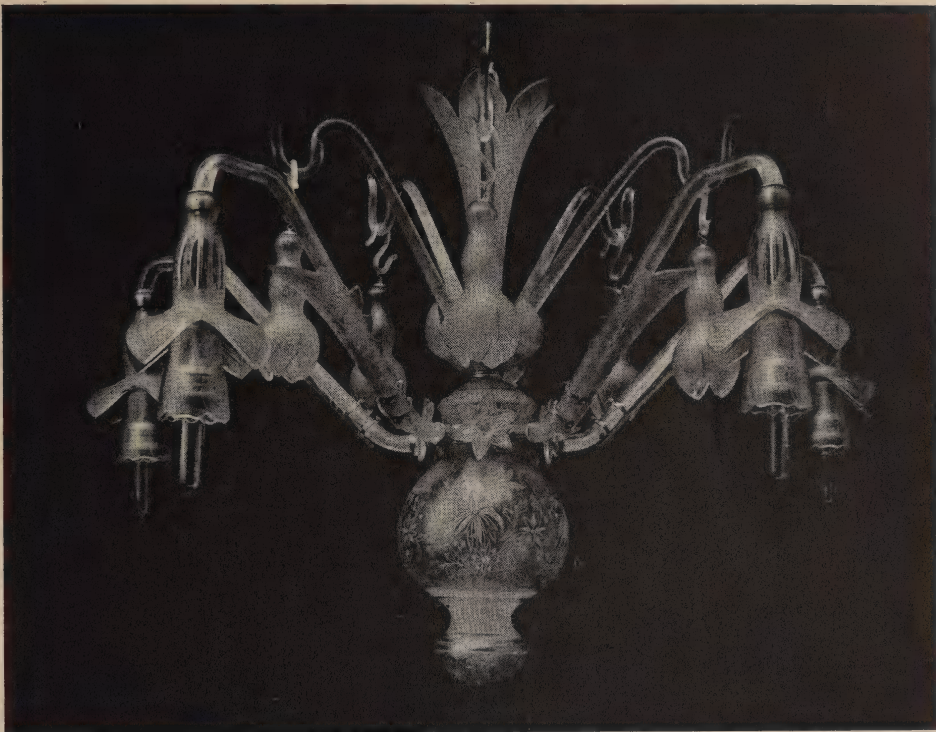
The excellent portrait of Mr. Moore was taken by means of his light, and shows still further its remarkable daylight qualities.

In point of absolute efficiency this form of light lies between the ordinary incandescent lamp of the present time and the luminous arc lamp, which represent the highest efficiency yet obtained in the production of light, being about 1 watt per mean spherical candle. For a majority of cases of interior lighting the luminous arc is out of the question, and the vacuum tube light may therefore be considered the most efficient source of any available for this purpose.

An item which is no less important than actual efficiency is that of maintenance. Mr. Moore says that his light once installed "will last forever." "Forever" is a long time; but it is difficult to see why his light as at present constructed should not under ordinary conditions last a lifetime. Glass is probably the nearest to being indestructible of any substance made by man, and the accessory apparatus used is so simple, and friction plays so little part in its operation, that it must in the nature of things be good for many years of service. Moreover, the first cost of installation is comparatively small. Mr. Moore states that he has installations of his present form of light that have been in constant operation for eleven months without apparent change or wear of any kind.

Should this form of light fulfill the expectations which may reasonably be deduced from its present performance, the question of illuminating engineering will be vastly simplified. To use Mr. Moore's striking expression, "Lighting will simply be a matter of glass plumbing."

In conclusion, the prophesy may be made in all confidence that the light of the future will emanate from incandescent gases.



Glass Fixtures in Art Nouveau Designs

In commenting upon the latest school of decorative art, to which the name Art Nouveau has been applied, the opinion was expressed in an article in the April issue of The Illuminating Engineer that the elementary principles of this school were right, and that much was to be expected from developments along this line. Such development has taken place to a far greater extent in Europe than in America; and very successful examples of it are to be found in decorations applied to wall paper, house furnishings, jewelry, book covers, etc. Among house furnishings may be included lighting fixtures of various kinds. Table lamps of such design have found their way to a considerable extent into the American market, but thus far the various types of chandeliers, wall brackets, and other fixtures, have scarcely been introduced at all.

It was recognized a long time ago, that glass is a particularly suitable material for ornamentation, and to a large degree also, the construction of lighting fixtures, and many examples of the periods of the Louises in France have scarcely been surpassed in recent times; in fact, practically all similar fixtures since have been mere imitations of these old designs. The great progress that has been made in glass manufacture since that period permits the construction of designs at the present time far surpassing in beauty anything that was then possible, and it is pleasing to note that the possibilities of the art noveau school have been realized by artisans in glass.

As stated in the article above referred to, the basis of this school of

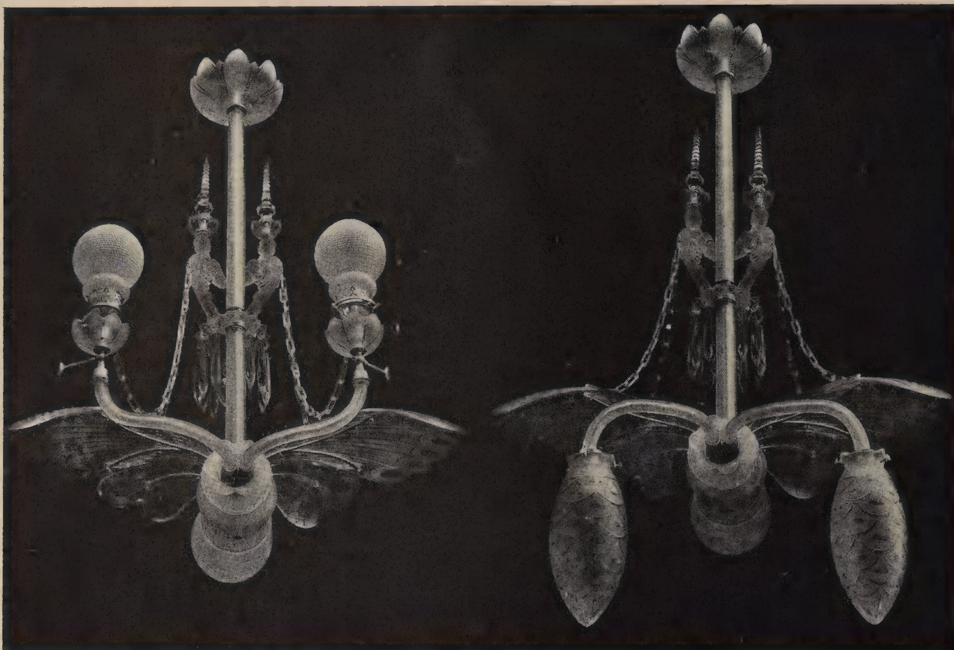


FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

art is the simulation of the beautiful forms and curves to be found in nature, without stripping them of their natural grace by reducing them to conventionalities. Both the animal and vegetable kingdom are drawn upon for models.

In Fig. 1 are shown designs suggested by the moth, its outstretched wings serving as a shade, a glass globe representing the body, while the antennæ are utilized as support for either Welsbach gas lamps or incandescent electrics, as may be required. What more appropriate theme for a fixture than the moth, which is the very emblem of the lover of light?

Fig. 2 shows a design based upon the forms of water lillies. The curves are exceedingly graceful, and the simulation sufficiently close to at once suggest the *motif*. The designs shown are for gas and electric, and it is specially worthy of notice that the gas fixture is quite as graceful and pleasing as the electric.

Fig. 2 shows two combination fixtures, one of them notable on account of utilizing the inverted incandescent gas burner. The construction of a combination fixture is a far more difficult problem from the artistic standpoint than of a single light fixture; and it will be seen by the illustration that the difficulties have been very successfully met in this case. The upright gas burners shown in the right-hand figure, however, show the brass part of the burner below, which is objectiontble. This defect could be easily remedied by suspending bead fringe around the shade holder of the burner.

FIG. 5.

Fig. 4 shows the working out of two different themes into very graceful electric designs. Bare lamps are

FIG. 6.

shown in use on these fixtures. From a decorative point of view they are less objectionable in these cases than on metal fixtures, since the filament of the lamp suggests the stamens in the flowers; this, however is hardly sufficient justification for their use and frosted lamps would be preferable.

Fig. 5 shows this school of art applied to single and two-light fixtures—a class of fixture which is extremely difficult to treat satisfactorily from a decorative point of view in metal.

Glass construction is by no means limited to chandeliers. In Fig. 6 is shown a number of side brackets which need no special description.

The possibilities of ornamentation in glass are almost limitless in the present advanced state of the art. It is hardly likely, however, that this construction will be produced in America, at least for some time to come. The European, especially the Bohemian glass worker, has the advantage of life-long training and vastly cheaper living; in fact, he has the great advantage which Holmes said was necessary for any genius, namely, that of having a grandfather that was also an artist. The most skilful Bohemian decorator makes about 75c. a day, on which he lives very snugly and contentedly, and in most cases apparently with far greater enjoyment than the American worker on five or ten times the amount. Even the present rate of duty, therefore, is not likely to foster any considerable industry in this line in this country.

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THE ATLANTIC CITY CONVENTION

The Twenty-ninth Convention of the National Electric Light Association is now a matter of history, which will be duly recorded in the published proceedings.

Such gatherings have two quite distinct aims—one looking toward the material prosperity of the interests involved, the other at purely social ends. The remark is often made that friendship has no part in business; the statement is an error. It is as impossible to eliminate the personal element from business transactions as it would be to eliminate the laws of supply and demand. Even the general tendency to conduct business under corporate management, which is notoriously soulless, will never result in the suppression of personal influence. The politician understands the advantage of making himself seen by those whose votes he seeks; and the successful business getter must be built on much the same lines as the successful politician. A personal interview of five minutes will usually produce more of an impression than hundreds of pages of correspondence or printed circulars.

The gathering of the various clans in conventions and association meeting, therefore, has a purpose and significance far beyond the mere coming together to listen to set papers. The conditions are usually most favorable to the growth of mutual good will and fair understanding. The strict routine of duties is relaxed; the artificial restraints and social distinctions between employer and employee, salesman and buyer, are laid aside, and there is every opportunity for a true "meeting of minds," which the legal profession assures us is the very essence of all bargains and contracts.

In this respect the Atlantic City Convention must be counted a thorough success. The location afforded an entire change of scene to practically all present; the weather was propitious, and the season of the year that in which "the young man's fancy lightly turns," instead of lumbering heavily along the ruts of every-day affairs.

All of the papers presented showed much careful thought and study in their preparation; and while no new ideas or discoveries of epoch-making importance were brought forth, the papers will furnish a substantial addition to the general information on the various subjects treated. Four of the papers presented were of particular interest to illuminating engineers, namely: "The Flaming Carbon Arc Lamp," by Mr. L. B. Marks, president of the Illuminating Engineering Society; "The Mercury Arc Rectifier System with Magnetite Lamps for Street Illumination," by W. S. Barstow; "Higher Efficiency Incandescent Lamps; Their Value and Effect on Central Station Service," by Francis W. Wilcox, and "New Illuminants," by Prof. H. E. Clifford. All of these papers will be found printed wholly or in abstract in another section of this issue.

There is one point for criticism in the general proceedings, and that is the lack of opportunity for discussing the papers presented. The discussion of a paper is often of as great value, sometimes even greater, than the paper itself, and to miss the opportunity afforded by a gathering of this kind is a most unfortunate circumstance. The papers presented are printed and cir-

culated before the time set for their reading, and it is presumed that everyone present is familiar with their contents. It seems, therefore, a useless formality to have the paper read in full before the meeting. The presentation of the papers is not in the nature of an oratorical contest, but is intended to impart information and afford an opportunity for discussion. Instead of attempting to read the papers through, why should not the author run over the subject, making comments of his own on various points, and leave the remainder of the time for listening to the opinions and experience of others. It cannot be expected that those presenting the papers will be professional readers; in many cases it is impossible, except for those in the immediate vicinity, even to follow their words; in fact, very few even attempt to, but simply read the paper as it is being presented. Furthermore, even the most eloquent reader would find it a dreary task to read to an audience a scientific paper with which they were already familiar and who were taking the words out of his mouth before they are spoken. The practice of presenting papers by reading is a worse than useless formality, and some way should be devised to dispense with it. The same criticism applies to the Illuminating Engineering Society, and, in fact, all other similar societies in which the papers are published before being presented.

Undoubtedly the most important question before the Convention was the problem of how best to meet the apparently rising tide of public interest in municipal ownership and rate legislation as applied to public service corporations. The paper dealing specifically with this problem, prepared by Mr. Everett W. Burdett, was a masterly treatment of the subject from the corporation point of view, and justly deserved the high measure of praise that was accorded to it. The attitude of the Convention on this subject may be summed up by the now common expression of "giving the people a square deal." Rates based upon a reasonable and fair remuneration to the corporations, a service seeking to give patrons the best possible returns for their money, and the introduction of approved devices for securing economies to the consumer as well as to the producer, characterized the general tenor of the discussion. To what extent this was a case of "making a virtue of necessity," we should not like to say; there are many others besides the devil who should have their due.

To give the matter another form of expression, illuminating engineering is to be given more consideration as a most valuable adjunct to sound financial engineering. Business keeping must be looked after as carefully as business getting; and the only way of accomplishing this is to keep the customer satisfied.

THE RATING OF LIGHT SOURCES

This seemingly interminable question is again brought to the fore by the advent of new sources, and modifications of old ones, and is suggested in particular by Mr. Wilcox's paper on Higher Efficiency Incandescent Lamps. The method of rating an incandescent lamp by its mean horizontal intensity has been assailed by photometricians ever since it has been in practice, and has been admitted to be illogical at one time or another by practically the whole lighting fraternity. It is not surprising, therefore, to find other methods brought forward to take its place; but to substitute for a measurement which is expressed in terms of luminous intensity a measurement which does not consider intensity at all is certainly not a step in advance. To rate a lamp by the watts which it consumes can be justified neither on the score of accuracy nor practicability. What would be thought of a steam engine manufacturer who should rate the power of his engine by the amount of coal burned? And yet such a rating would be every whit as reasonable as to rate an electric lamp by the watts of current consumed.

The method of rating higher efficiency lamps based upon this method is self-contradictory. Thus, an example is given of a lamp rated at 50 watts and 112, 110, and 108 volts. How can a lamp be a 50-watt lamp on all three of these voltages? It is simply an absurdity. Mr. Wilcox states that "candle-power values are not given on the tables, as they have become confusing, due to the use of the term in so many varied ways." It is true that candle-power is an indefinite and ambiguous term, but in the present state of photometry, it is the only unit that is familiar to the public, and dropping it altogether is not likely to make it better understood. A single qualifying word is sufficient to make the term perfectly definite. Mean spherical candle-power, readily abbreviated to M. S. C. P., is a perfectly definite quantity, and is the only photometric quantity with which it is possible to express the absolute efficiency of a light-source. The only data which gives positive information to the customer are the mean spherical candle-power, which is equivalent to the total amount of light emitted, and the watts consumed, at a given voltage or voltages; and this information is not so elaborate as to prevent its being placed upon an ordinary size label, even where three different voltages are to be used. Where accessories, such as reflectors or globes, are to be used the distribution curve and mean lower hemispherical efficiencies should be given, so that the illuminating engineer or user can have them as a basis for their intelligent selection and use in any given installation.

The fact that the old-fashioned flame gas burners are generally rated by the cubic feet of gas they burn is no excuse for the electric lamp maker to dodge an exact marking of his lamps. The rating of gas burners in this way is as faulty as the rating of electric lamps by wattage; the one fault does not correct the other. The rating of lamps by reflected rays, either directly or by inference, should likewise be rejected, as it affords wide opportunities for deception.

We repeat: there is but one indisputable and scientific method of rating light-sources, and that is by the total quantity of light emitted. This quantity, compared with the quantity of illuminant used, gives the absolute efficiency.

In the case of the new forms of arc-lamps also, the tendency seems to be to dodge the issue and throw the whole subject into greater confusion rather than to take advantage of the opportunity to establish a sane and uniform practice. Thus, in his paper on "The Magnetite Arc Lamp," Mr. Barstow says:

> "In the use of the magnetite system a commercial question arises which, after very careful consideration, should be definitely answered before the system is adopted to any great extent. I refer to the specifications used in the present public lighting contracts. About fifteen years ago considerable thought was given to the subject by this association, resulting in a campaign of public education which produced the proper result at that time of rating street arc lamps by the 'watts in the arc' and dropping out of contracts the terms 'normal candle-power.'
>
> "The question * * * under what specifications the illumination should be furnished is a broad one and is a matter that should be carefully considered at this time, so that the introduction of this new system shall be accompanied by a proper standard form of specifications."

Whether the public education which resulted in the rating of an arc lamp by the "watts in the arc," in place of "normal candle-power" may be considered a "proper result" is open to serious doubt. True, "normal candle-power" was a term which was flagrantly misused, as was well expressed in the now classical joke of the engineer who explained that 2,000 normal candle-power was one which threw 500 candle-power down each of the four parts of intersecting streets. The use of the word "normal" in this connection was an exaggerated case of a contradiction in terms; if the term had been written *ab*normal candle-power it would have

come much nearer expressing the truth.

Fixing the price of public lighting by watts in the arc is a method of juggling scientific terms for which there is absolutely no warrant at the present time. What the public want, and what they are supposed to pay for, is illumination; and there is no reason in theory why the amount they pay should not be based absolutely upon the illumination obtained. Illumination upon a defined plane, which may be either the street, the sidewalk, or a plane at any height above these, is a quantity susceptible to comparatively easy and accurate determination; and the specification of either an average, or a minimum illumination on such a plane could be readily specified and the results obtained checked up.

STREET LIGHTING BY INCANDESCENT LAMPS

This method of street lighting is attracting a considerable amount of attention at the present time, as is shown by the information treated of in the paper on the subject presented before the Illuminating Engineering Society by Messrs. Underwood and Lansingh, and the various installations that are being placed in different parts of the country. This tendency is a belated acknowledgement of the literally "glaring" defects of the arc lamp for most purposes of street lighting, and the corresponding advantages of the incandescent lamp.

In the various cases cited in Messrs. Underwood and Lansingh's paper this method of illumination does not seem to be considered seriously by the cities using it, but to have been placed rather as an attractive form of street decoration, the question of illumination being secondary. That this purpose has been accomplished is evident from the illustrations shown. It would be unfortunate, however, to have this view of incandescent street illumination obtain a general acceptance among those in charge of municipal lighting. In actual fact the method has many points of superiority over illumination by arc lamps, especially since the advent of incandescent lamps of much higher practical efficiencies than have heretofore been obtainable—a matter which was fully set forth in Mr. Wilcox's paper presented at the same meeting.

In the use of incandescent lamps the question of the fixture or support for the lamp is of as great importance as in the case of interior lighting; and it is in this regard that the installations discussed in the paper referred to are open to the most severe criticism. The illuminating engineer has justly inveighed against the prevailing absurdities of fixtures designed for interior lighting, but it would be difficult to find a more aggravated example of faulty design and construction of fixture than is embodied in the lamp posts designed for street illumination.

In the first place, they all hold the lamp in an upright position, and in most cases have a large, supposedly ornamental support underneath, thus intercepting a considerable portion of the light that is most needed to illuminate the pavement. In the second place, the lamps, instead of being distributed singly along the pavement, are bunched together in clusters on the standards, thus absolutely nullifying the great advantage possessed by incandescent lamps, namely, ability to divide the light up into any desired number of small units distributed at will. Third, by arranging several lamps, fitted with comparatively large diffusing globes, upon the post, a large amount of the light of any given lamp is intercepted by the others in the cluster and thus wasted. At the least calculation three-fourths of the light produced is completely lost so far as any useful purpose is concerned, by the fixtures shown. As a consequence, the efficiency of the illumination is ridiculously low: in fact, it would be difficult to produce an illumination with a greater waste of light and current than by the methods described. The same amount of current would

distribute arc lamps so thickly along the street as to light them beyond all necessity and reason.

Such useless extravagance is a menace to the advancement of improved methods of street illumination, and central stations will do well to strive to counteract it. The entire fault may be laid to the door of the designer. If the artistic ability of these designers equalled their ignorance of the subject of illumination, their designs would surpass anything that the world has ever seen. But it is not to be assumed on the other hand that efficient lighting must of necessity be ugly. All that is required is for the designer to have some instruction in the simplest principles of illuminating engineering, or for the illuminating engineer to have a supervising authority over the designer.

From the true artistic standpoint the designs used must be considered absolute failures, since they defeat the prime purpose for which they were intended, which is to support lamps for illuminating streets. There is no possible reason why a fixture designed to secure the highest possible results from the lamps used should not be at the same time as artistic as the limits of cost will permit. As to cost, the amount wasted in current on the present fixtures would pay the interest on a bronze statue for each lamp post. A system thus designed could successfully compete in efficiency with the best of arc systems producing anything like equal results, and would have the great advantage of being free from glare, having less dense shadows, and a more nearly uniform intensity.

The matter of accessories in the way of globes or reflectors is also one which demands consideration from an illuminating engineering standpoint, as well as from the decorative. The use of opalesced or frosted globes is scarcely justifiable under ordinary conditions, as it reduces actual efficiency, as well as the life of the lamp, and does not improve in any way the distribution of light. A reflector of some suitable material designed so as to aid to the largest extent in properly distributing the light of the lamp, is the logical accessory to use.

COLOR OF LIGHT AS A FACTOR IN EFFICIENCY

The commercial advent of the luminous arc lamp, with its approximately monochromatic light, and the apparently successful production of the vacuum tube light, which also differs in color value from the more familiar light-sources, has brought prominently to attention the relation between color and efficiency. To a question as to the possibility of securing a light of daylight quality from his vacuum tube system, Mr. Moore replied very pertinently, "that if illuminating engineers would decide upon a standard spectrum for illumination, he would produce it; but if so-called white light were demanded, the efficiency would naturally be reduced, for the reason that the ultimate measurement of light made by the eye is of such a nature that the yellow rays have a much higher value than those of any other color; or in other words, if an equal visual impression is to be produced by the other colored rays considerably more energy must be put into them." The same thing applies to the luminous arc lamp; it is an easy enough matter to produce carbons which will give practically daylight values, but the efficiency is thereby cut in half. This is a physiological necessity from which there is absolutely no escape. For every purpose therefore in which distinctions of color are not of prime importance, light of a distinctly yellowish color is likely to be the dominant artificial light for a long time to come. That a light of this color produces an effect that is agreeable to the eyes is a further point in its favor. Artificial light-sources of a blue or greenish cast are therefore not likely to achieve a position of practical importance, both from lack of efficiency, and unsatisfactory physiological and visual effect.

THE NEED FOR THE ILLUMINATING ENGINEER

We published in the May issue an abstract of Mr. Leon Gaster's article in the *Electrical Magazine* setting forth the need for the illuminating engineer. In the conclusion of the article, which appears in the May number of the *Electrical Magazine,* Mr. Gaster goes still further in his suggestions and points out the many advantages that would be derived from creating an "Institution"—that is, a permanent home for an illuminating engineering society, where facilities for exhibiting various luminants and illuminating appliances could be carried out.

It will interest our foreign readers, at least, to learn that a magnificent building is being erected in New York to house the various scientific societies, and that, when the plans were being worked out, an illuminating engineer, who is a prominent member of one of the largest of the societies to be domiciled in the new building, suggested the propriety of having the illumination laid out in accordance with engineering principles, and offered his own services for that purpose. The matter was considered by the directors, who decided that the services of an illuminating engineer were entirely superfluous. Nevertheless, we would respectfully submit Mr. Gaster's suggestions to the special consideration of the aforesaid directors in particular, and to our readers in general.

From what has been said before, I would venture to suggest that the time is ripe to inaugurate a similar illuminating society in this country. The merits of the different illuminants could then be properly studied and the useful application be defined for each of them. An "Institution" could afterwards be created, in which all the different illuminants would have a fair chance of being shown under the best conditions and their relative merits properly gauged. A permanent exhibition would thereby be formed which, to my mind, would be of great benefit to consumers, and of exceedingly important educational value to the future illuminating engineer. For the present he has not enough opportunity of being educated to become such an expert, and this will then be afforded to him through lectures by the best professors and known experts, familiar with the different illuminants. He would then know not only one of the illuminants, as is mostly the case at present, but would become perfectly conversant with the merits and faults of all, so that he could conscientiously and properly advise his clients as to the actual merits of the different illuminants for the different purposes in view.

Without wishing to dictate any course of action, I should think that a powerful body such as the London County Council, for example, may in time see its way to grant a fund for the building and maintenance of such a permanent home for the different illuminants. The many local authorities which are owners of gas and electric plant will be only too glad to know how they can reasonably utilize the different lighting commodities to the best advantage of the rate-payers. We have an example in the street lighting question, in which the differences of opinion are so great that one feels the necessity of some central authority to advise on these matters, and to settle what is best adapted for the different kinds of streets in towns. London may reasonably become the leader.

The technical side, however, viz., the close investigation of the relative value of the different illuminants as regards candle-power given out, the consumption of energy, electric, gas, etc., and other such questions, can be conveniently undertaken and settled by the National Physical Laboratory, the work being done for the benefit of the public. The practical application of the different illuminants could then be constantly demonstrated at the future illuminating Institution which I am picturing, conducted by properly qualified and trained illuminating engineers. A Museum might advantageously be established, attached to the Institution, in which the progress and development of the different systems of illumination could be kept on record. Naturally, I should also like to see there a specially well equipped library for reference.

The formation of an Illuminating Engineering Society ought to receive a hearty support from the council of the gas and electric institutions, and I should think the newly formed British Science Guild, whose object is to try and convince the people by means of publications and meetings of the necessity of applying the methods of science to all branches of human endeavor. For promoting and extending the application of scientific principles to industrial and general purposes, and furthering the progress and increasing the welfare of the Empire, it should take this opportunity and utilize its great influence in encouraging the formation of this society.

Correspondence

FROM OUR SPECIAL LONDON CORRESPONDENT

A RECORDING GAS METER.

Perhaps no mechanical device has been treated with such contumely and suspicion as the gas meter. The consumer has always been sure that in some inexplicable way the meter registered more gas than was consumed, and this in the face of the most stringent regulations enforced in Great Britain by acts of Parliament by which the consumer can demand to have the meter tested; but still no satisfaction is derived, and the gas meter remains an "evil thing" in the eyes of many. It would seem almost impossible to teach a man or woman to read a meter and then to work out the simple subtraction of the reading of the previous quarter and so arrive at the quantity of gas consumed.

Much popularity has been earned among cyclists for the Veeder cyclometer, a mileage recorder. The company which manufactures these very useful and simple accessories has been devoting time and money to the perfection of a gas meter counter of a similar principle.

These counters show at a glance the state of the meter, and we understand that any pressure that is sufficient to move the ordinary mechanism of the meter itself will operate the counter. The register is shown in decimals; and the counters are made for meters of all standard sizes. In the 3 and 5 light size the dial records up to 10,000 cubic feet in units of 10 feet; there is in addition, a 2-foot proving hand. Meters of this size are also made with an auxiliary hand for proving, registering 0.2 cubic foot per each revolution.

This hand is necessary in some districts in order to comply with the legal requirements, and is also specially useful as an aid to the detection of leakage. In 10 and 20 light meters the dial records up to 1,000,000 cubic feet in units of 100 feet, the proving hand registering 5 feet. In the 30 light meter the proving hand registers 10 feet, and in the 45 to 60 light sizes 20 feet is registered.

The 100, 150, 200 and 300 light meters record up to 10,000,000 feet, the first three sizes having proving hands of 50 feet and the 300 light 100 feet. The fitting of the Veeder Meter-Counters entails but a small extra cost and appears likely to revolutionize the method of recording gas measurements.

RAILWAY CARRIAGE LIGHTING.

At a meeting of gas engineers, held at Manchester, a paper was read on the "Methods of Lighting Railway Carriages." The particular apparatus described was that in use on one of the principal British railways—the Lancashire and Yorkshire. It consisted of a small cylinder containing about 10 cubic feet of oil gas at 50 lbs. pressure. The first lamp was fitted with two No. 000 Bray's burners giving six candles illuminating power with a consumption of 1 cubic feet at 12 lbs. pressure; a second lamp was fitted with a regenerative burner (the Wenham type), giving 12 candles, and the third an ordinary inverted incandescent burner giving a duty of 36 candles.

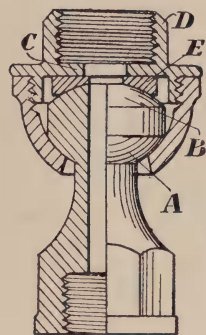
The inverted incandescent burner has been found, when practically tried, to give better results than the vertical burner—being 36 candles per 0.5 cubic foot of gas per hour. The approximate life of such a mantle, it was said, was 200 hours and the distance covered by the carriage about 1,300 miles.

The burner used for compressed coal gas was regulated for a consumption of 1.3 to 0.4 cubic feet of gas per hour at a pressure of 71 lbs., produc-

ing a light of 32 candles. Compressed oil gas has been in use for railway carriage lighting for very nearly thirty years, and is still in general use throughout the British Empire. Few railway carriages are fitted with the electric light and fewer still with the inverted gas mantle; in our opinion that special form of mantle lends itself particularly to the purpose of railway carriage illumination.

ACETYLENE GAS AS AN ILLUMINANT.

Acetylene gas seems to have pushed air-gas out of the field. There are now several very excellent plants for the manufacture of acetylene gas on a small scale; and several small villages have installations which are operated through the ordinary distributing mains and services. At the moment of writing one such plant particularly occurs to us in Patsey, a small town in Ireland. Some 70 consumers are supplied and the charge per 100 (one hundred) cubic feet is $1.45; so successful have been the operators that a dividend of 3½ per cent. per annum has been paid upon a capital of $7,200. Quite recently Sir Charles Stewart Forbes read a paper on "The Generation and Use of Acetylene" before the newly formed association of engineers in charge, in the course of which he touched upon the question of cost and said: "I take the burner used as one of the ordinary type consuming ½ a cubic foot per hour. I take good carbide which should yield an average of 4.75 cubic feet of gas per lb., and I take it that the carbide can be delivered into a store for $82.00 per car. With these data I work out that the gas costs $0.38346 of a penny (2 cents) per cubic foot—practically 1/3 of a penny; the ½ foot burners will cost $0.19173 of a penny per hour per carbide only." Sir Charles added that there were the charges for talons which was infinitesimal and that at a cost of ¼d. (½ cent) per hour, a very fine light could be obtained. A special burner has been put on the market by Messrs. George Bray & Co., which gives most satisfactory results with gas at a pressure of 3 inches of water. When using acetylene gas with incandescent burners, 4 inches is the lowest pressure at which satisfactory illumination can be obtained. Acetylene gas consumed in incandescent burners, is considerably less in quantity per candle-power than when used in the ordinary burner.



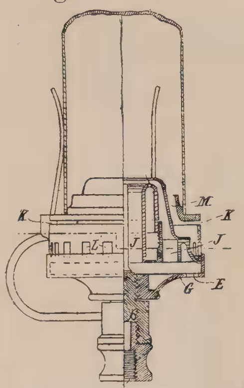
A SAFE CUP AND BALL JOINT.

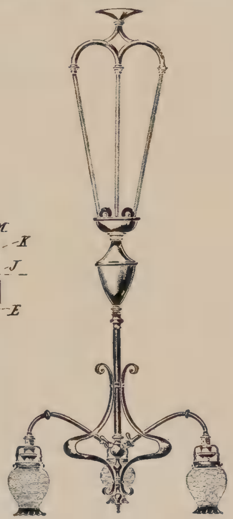
All interested in gas illumination know the want of a perfect cup and ball joint. The illustration shows a new form which has recently been patented by an English firm; in this joint there is no spring; in fact the half ball has been replaced by a complete ball, so preventing any leakage when the pendant is tilted over too far, or when it is lifted and the needle taken off the spring. The upper side of the ball A, has a spherical surface B, and betwen this surface and an internal flange C, on the Union D, is placed a washer. The upper surface of this washer, as will be seen, is flat and the underside is cupped to fit the upper surface of the ball so allowing considerable play for the pendant.

THREE-LIGHT ADJUSTABLE PENDANT.

It is quite probable that the introduction of the graceful electroliers has done a great deal to induce the manufacturers of gas fittings to give the consumer something better than the inartistic chandelier and the nineteenth gas pendant. The illustration shows a pendant fitted with a patent flexible central counter-balance, so arranged that the lamps may be placed

at any level by a touch of the hand. These are fitted with inverted incandescent burners and made in many designs.





A NEW STANDARD ARGAND BURNER.

With the first of January of this year the London Metropolitan Gas Referees adopted a new standard burner for testing purposes; its general form will be gathered from the illustration. At some future date the conditions under which the burner is used and a fuller description shall be given, if the Edison permits. In this burner the air supply to the inner and outer surfaces of the flame is controlled by an adjustable disc; a method has also been adjusted of regulating the air supply in three currents. The inner and outer supplies of air are given through the channels J, and the third supply through the parts L, and the channels K and M. The adjustable disc G has openings at E, for the passage of air to the channel J, and an upstanding flange on the disc controls the third air supply through the parts L. For the poorest gases the channel K, provides sufficient air, but when richer gases are required to be consumed, the covering glass disc G, by means of which more air is given to the outer and inner edges of the flame, also uncovers the part L, and admits an extra suply of air to the channel M. The advent of this burner, which is the invention of Mr. C. C. Carpenter, M. Inst. C.E. (Eng.), has given great satisfaction to all gas engineers. The "London Argand," which prior to January last was the standard burner for testing purposes, had for a long time been quite unsuitable for tests of the gas burned in incandescent or clear high-power burners.

CHAS. W. HASTINGS.
(Ed. *Gas Engineers' Magazine.*)

FROM OUR READERS

To the Editor of THE ILLUMINATING ENGINEER.

Sir:

On pages 209 and 210 in the May issue of THE ILLUMINATING ENGINEER, we note a criticism on the method of desk lighting recommended by us in our article in the *Electrical World* of May 5, 1906. You illustrate a method which you say is preferable (see Fig. 2, page 210). We have experimented at length with the lamp, reflector and covering arranged as illustrated and have been unable to find any position of the lamp anywhere near that which you show which gives anything but exceedingly bad results. We have not been able to discover any position where the worker at the desk would not receive a direct glare from at least a part of the unshaded lamp, and that, too, from an angle where he cannot possibly avoid it while he is working at the desk. We also find that the general illumination over the surface of the desk is more uniform with the arrangement we advocate. Yours produces a very brightly illuminated area on one side of the desk leaving the other side dark by contrast.

With the lamp placed, according to our specifications, the eyebrows of the person at the desk entirely protect the eyes. The light does not shine in the eye at all in any ordinary working position. The writers have been working by lights, placed as recommended for several years, and find the arrangement so much more comfortable than anything else that has been proposed that they still remain firm in the

belief that the arrangement they suggest is the best obtainable for ordinary everyday work, although they are willing to change their opinion the moment some one can suggest a method which, after having a practical trial, will prove better.

Chicago, Ill. J. R. CRAVATH.
V. R. LANSINGH.
New York, N. Y.

"Who shall decide where doctors disagree?" Probably the patient—if he lives to tell the tale. We will, therefore, try to state the facts as clearly as possible in the matter under dispute, and leave to our readers the decision as to the relative merits of the methods of desk lighting advocated.

Our correspondents say that they "have not been able to discover any position where the worker at the desk would not recive a direct glare from at least a part of the unshaded lamp." In taking the photograph we were careful to adjust the height of the lens to the height of the eye of a person sitting in an ordinary desk chair, and the photo itself shows that it was taken directly in front. Anything that would be visible to the eye in this position must therefore appear in the photograph; we simply ask the reader

FIG. I.—DESK LIGHT RECOMMENDED BY "THE ILLUMINATING ENGINEER."

FIG. 2.—DESK LIGHT RECOMMENDED BY CRAVATH & LANSINGH.

to look for any part of the unshaded lamp, and, furthermore, to observe the perspective and judge whether moving any nearer to the desk would bring the lamp into view.

Our correspondents also say that "Yours produces a very brilliant illuminated area on one side of the desk, leaving the other side dark by contrast." In answer to this, we will state that the photograph was taken in a room illuminated to a very moderate degree by artificial light, as it would ordinarily be in an office, the illumination on the desk being produced by the desk-light itself, so that it represents exactly the conditions that would be found in regular use; and again we ask our readers to find the dark spot referred to.

Lastly, let it be remembered that "halation" in a photograph is the counterpart of "glare" in vision. The desk as shown in Fig. 2, which is the arrangement recommended by our correspondents, was photographed by the light of the desk lamp alone. As will be seen, the halation is so strong as to entirely obliterate the lamp and reflector. What would be the effect on the eve in working under such a light? We can only say, try it—*but not too long.*

Facts and Fancies

Mr. G. W. Pearce, now connected with the *New York Sun*, is a veteran in the lighting field, and has been a keen observer of the remarkable development in illumination that has taken place since the advent of the electric lamp. Mr. Pearce has given us the following anecdote of one of the greatest architects which America has ever produced, which will certainly interest ILLUMINATING ENGINEER readers.

"The stalactite form of glass shade for the incandescent lamp was designed by the great architect, Henry Hobson Richardson, whose noble Romanesque buildings, Trinity Church, Boston, the Capitol at Albany, the court house at Pittsburg, and many other superb examples of good architecture adorn the country. In his early days, as a struggling architect in this city, Richardson designed lamp and gas shades for several well-known manufacturers during the late sixties and early seventies. In his prosperous days, after the building of Trinity Church had placed him in the forefront of architects, Richardson related that one morning he awakened in his small hall room in a Brooklyn lodging house and realized that his entire capital in cash was five cents, and that his sole commercial assets in shape for quick sale were several designs for gas globes which he had carefully colored in water colors for submission to Tiffany & Co., the jewelers, who then made gas fixtures. Richardson spent three cents for rolls, the remainder of his cash for ferry fare, and walked to Tiffany's, then at 550 Broadway. But no sale was effected. Richardson then offered to go to work as a draughtsman to design fixtures and globes at $20 a week. That proffer was rejected, and Richardson went out and walked the town all day in the bitter cold, overcoatless and hungry, vainly endeavoring to find a market for his gas globe designs, or employment with a gas fixture house. He went without food for two days, and then sold his gas globe designs and a few designs for kerosene lamps to Ives & Co., a firm many years out of business, but then widely known. For that firm Richardson designed a fine catalogue, the first in the American lamp trade that was gotten out in colors, and which was so truly artistic, and embodied so many fine designs by Richardson, that a great business resulted therefrom both in this country and abroad.

"As early as the first commercial success of the incandescent electric lamp, in 1879, Richardson predicted that it was the light of the future, and for several friends who installed the system he designed beautiful shades that were made to order by the old New England Glass Co., the Mount Washington Glass Works, and other makers.

"Richardson designed the stalactite, in the first instance, to shade a series of arc lamps provided for a lawn festival by one of his neighbors at Brookline, Mass. The effect was very fine, as the stalactites were made of the highest grade of lead glass flashed with ruby, made with chloride of gold, and overset with bandings of opalescent, turquoise, and uranium glass of the sorts made in rods for the manufacturers of artificial jewels. His first designs in stalactites for the incandescent electric light were made for his friend Frederick L. Ames, Boston, the first large capitalist in New England who engaged in the business that developed into the present gigantic Edison Electric Light Co., of Boston. These designs covered the whole field of designing in stalactites, globes and shades that embraces the present-day field of design.

"At that time Richardson was the

only architect in the United States who had an accurate and comprehensive knowledge of the sciences of chemistry and electricity. He had studied both of those departments of physics at Harvard College, and had ever afterward conducted experiments in electricity as time served for the gratification of his taste. He came rightly by the love of the science of electricity, as he was a great grandson of the renowned Dr. Joseph Priestley, the discoverer of oxygen, and to whom we owe the knowledge of the fact that an acid is formed when electric sparks are made to pass for some time through a given bulk of common air, which discovery afterward led to Cavendish's discovery of nitric acid and to Dr. Colton's discovery of nitrous oxide gas, which was the first anesthetic used in the world. It was a source of pride to Richardson that his great grandfather in heeding the advice of Benjamin Franklin, in London in 1765, to bring out in book form his lectures on "The History of the Present State of Electricity," published at London, 1767, had in great part helped to found arts and sciences which had benefited countless millions of mankind.

"This great architect used to relate that in his boyhood he had talked with an old man who as an apprentice had helped make the last electrical apparatus with which the great Franklin and Dr. Priestley made their last experiments together, and that this apprentice afterward made apparatus for S. F. B. Morse, Alfred Vail and Ezra Cornell, founder of Cornell University, and lived to see in his last year of life, a commercially successful arc lamp in front of the old home of Franklin. This one human life linked the discoverers of Priestley and Franklin with the inventions of Brush and Edison."

ULTRA-VIOLET GLASSES

A large optical dealer in New York has the following to say in regard to the glass used for spectacles:

In the manufacture of lenses for spectacles, very little progress has been made in recent years. The great mechanical improvements made in spectacles have been chiefly in the direction of ingenious devices for holding glasses firmly on the nose of the wearer with ease and comfort, in increased lightness of the frames or mountings without loss of durability, in neatness of appearance, and conformity to facial dimensions. In this respect the American optician has certainly earned and holds first place.

With the lenses themselves, however, the limit of perfection had apparently been reached. The grinding of various curves on lenses to obtain the desired focus, being purely a mechanical process, no very startling improvements have been made for many years, painstaking attention to details and carefulness of workmanship being the chief difference between the product of the best and the ordinary optician.

It is very evident, therefore, that if any decided improvement can be made in spectacle lenses it must be in the material itself from which the lenses are ground. It was long ago discovered that the spectrum obtained by means of the reflecting diffraction grating, or of a rock crystal prism, showed a powerful and extended actinic region, invisible to eyesight and beyond the violet, whose very existence had not been suspected in the days when glass prisms alone were employed for spectroscopic purposes. This is the ultra violet ray region, now known to be far the most powerful in chemical effect of the entire parcel of rays.

Until very recently all kinds of optical glass have been absolutely impervious to most of the ultra violet rays, and even in other regions they are so little pervious to any but the yellow and green rays, that they might be and are called yellow and green glass. All glass without exception shows color when viewed through a spectroscope. The purest of optical crown glass showing a green, and the whitest of optical flint glass showing a yellow ray. The finest specimens of both kinds of optical glass show an enormous absorption in all regions, but the yellow, when examined spectroscopically. The optical properties of different types of glass are demonstrated by five bright lines of the spectrum, easy of production at any moment by artificial light and known as the red potassium, the sodium line, and the three bright lines of the hydrogen spectrum.

The aim of scientific glass makers has been to obtain a material absolutely colorless, of extreme hardness and of great permeability to those rays of the spectrum of short wave length which are usually lost by absorption in passing through ordinary types of optical glass.

The newly discovered ultra violet glass fulfils all the above conditions. It is of

extraordinary clearness, of exceeding hardness, takes a high polish and will not scratch easily, and spectroscopic tests show that it is readily distinguished from existing ordinary optical glasses by the quality of considerably intensified permeability to ultra violet rays, that is, rays of a wave length below 400 ($u\ u$), and not only transmits the blue, violet and ultra violet rays of the spectrum, but extinguishes the red, infra-red and yellow rays, which are the chemical heat-rays, and thus actually conveys a comparatively cool ray of light through the eye to the retina.

The advantages of spectacle lenses made of ultra violet glass are of the utmost importance in the preservation of eyesight. Their crystal transparency gives a most brilliant image without irritation or fatigue. Their extreme hardness and high polish make them less liable to breakage and they are cool and soothing to the eye.

The advisability of allowing the violet and ultra-violet rays to enter the eye, however, is very questionable. In fact, there seems every reason to believe that glasses which would intercept these invisible rays would be of great advantage. The matter is an interesting one, as drawing attention to the fact that it would be possible to compound a glass of such selective absorption as to transmit only the rays which are most useful in producing the visual impression, while absorbing those which only serve to strain or fatigue the eye.

A NOVEL LAMP GLOBE

The illustration herewith shows a device that is termed by the *Scientific American* "A Novel Reflecting Lamp Globe."

As to the novelty of the device there is little room for dispute, the novelty consisting in an almost literal disregard of the scriptural injunction against putting a light under a bushel. It would be interesting to know what portion of the light finally succeeds in escaping through the minute windows; while as for artistic appearance, it might perhaps go along with that class of globes which Dr. Louis Bell so aptly described as "suitable for use over onyx bars inlaid with silver dollars." The contemplation of even the picture is calculated to give an illuminating engineer a nervous chill.

IT HAPPENED IN AUSTRALIA.

"Mr. Wells proceeds to find the leak of gas. From what followed we presume he found it; we do not expect—Mr. Wellsbach."—*Electrical Times* (London).

The Illuminating Engineering Society

PAPER READ AT THE MEETING HELD IN NEW YORK, JUNE 8, 1906, AND DISCUSSIONS OF THE PAPERS READ AT THE PREVIOUS MEETING

SOME PHYSIOLOGICAL FACTORS IN ILLUMINATION AND PHOTOMETRY

By Dr. Louis Bell.

The fundamental difficulty in the scientific study of illumination is that one has to define physical quantities in physiological terms. Illumination in all its phases deals with the sensation of sight, and between the one and the other there are no fixed relations, but only variable approximations. One can, therefore, rely upon only average conditions, restricted within somewhat narrow limits. The purpose of this paper is to point out some of the bearings of physiological optics upon practical illumination, its measurement and the limitations of its efficency.

Save for the effects of accommodation and convenience in determining vision in three dimensions, we see things wholly by their differences in color and luminosity. If two objects are of the same color and luminosity they cease to be separately distinguished, and as they approach this condition they become progressively more and more indistinct as individual forms. If the difference of luminosity is small the color difference must be increased to secure visibility, and *vice versa*. It is perfectly astonishing how objects of similar luminosity and quite different color or of similar color and quite different real luminosity can melt into the general landscape as soon as they are beyond the range of material help from binocular vision.

According to Fechner's law, the human eye can perceive a fixed fractional difference of illumination, irrespective, within wide limits of its absolute amount. This fraction varies in general from about 1 per cent. to about 0.55 per cent. assuming ordinary sources of illumination and normal eyes.

Now for the purposes of practical lighting, the illumination should be generally kept within the range for which Fechner's law holds good, and once well within that range of normal sensibility nothing is gained virtually by increasing the strength of the illumination, so far as difference of luminosity is concerned.

But this is not all for visual acuity also enters the problem. By this one means the power of discriminating fine details, assuming strong contrast between them. This although it depends primarily on the retinal structure also varies considerably with the illumination as everyone knows. There is also a tolerably obvious but little understood relation between sensation and the area of the retinal image. The smaller the image the brighter must it be to produce a distinct sensation. Thus, for example, small objects seem distinct enough at moderate distances and blend into the general landscape as their distances increase. In artificial illumination this phenomenon is seldom of importance. In order to see things with satisfactory distinctness the illumination must be sufficient to bring the eye to its normal acuity and to give to Fechner's fraction somewhere nearly its normal value. A curious case is cited by Kreuchel, in which a patient complained of not being able to see well enough to get about. On examination the visual field and visual acuity were normal, but a special test showed that for his eye Fechner's fraction was about 1/10, instead of 1/100, and hence only strongly contrasted objects were clearly visible to him.

Starting now from Fechner's fraction and from the facts of visual acu-

ity let us see whether a logical basis for illumination can be devised which shall thus rest not upon purely empirical observations of good and bad lighting, but upon the general data of physical and physiological optics. Thanks to the work of König and Brodhun, and of Uhthoff one can get a clear idea of the variation of Fechner's fraction and of visual acuity with the strength of illumination. In Fig. 1

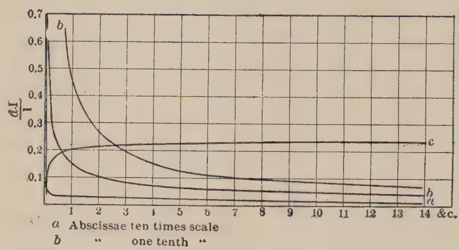


FIG. 1.

these relations are plotted with the illuminations in foot-candles, as abscissæ. Curves *a* and *b* relate to Fechner's fraction, with $\frac{dI}{I}$ as ordinates.

Curve *a* shows the variations found up to 140 foot-candles, while curve *b* is on 100 times the scale as regards abscissæ, running therefore to 1.40 foot-candle. I use the foot-candle as unit, not because I prefer it, but because the English standard candle is the only legal unit for practical use.

A glance at curve *a* shows at once that by the time the illumination has reached the neighborhood of 1 foot-candle the curve is turning clearly toward the horizontal and that beyond, say 5 foot-candles, the decrease in the sensibility is very slow indeed. Curve *b*, in fact, shows that the curve is rapidly getting asymptotic at even 1 foot-candle. These curves are for white light, and the question may naturally be asked as to whether they also hold for colored light. At low intensities they do not, the sensibility for red being considerably less, and for blue somewhat greater than is here shown. Curve *b'* shows the approximate values for deep crimson. Eyes differ considerably in absolute, and in color sensibility, but *b'* will give an approximate notion of the color effect at its worst. At high intensities, say about 25 foot-candles, the color curves run together.

Difference of visibility in colored objects, however, is only in small measure due to the facts here noted, being mainly chargeable to mere differences in reflecting power.

Curve *c*, Fig. 1, shows the variation of visual acuity up to 14-foot-candles, the ordinates being purely empirical values. It at once appears that the increase in acuity is very slow above about 1 foot-candle, but goes on increasing slightly, like the shade perception, above all working values of the illumination. In extremely intense light, several thousand foot-candles, the sensibility decreases slowly, and probably also the acuity, but these upper limits are quite beyond the limits of ordinary illumination.

It therefore plainly appears that at 1 or 2 foot-candles the eye is working so near its normal sensibility that further increase in illumination is of relatively very small value.

The essential point in good seeing, however, is that the values here specified should be those affecting the eye and not merely those by which objects are illuminated.

Since objects are seen in virtue of differences of reflected light the illumination which affects the eye is determined by the co-efficients of diffuse reflection of the objects in the field of view.

The light reflected from any object is I K where I is the incident illumination, and for this to have the value required by the visual conditions just indicated. $I = \frac{a}{K}$ where *a* is the absolute factor just found. For example, taking $a = 1.5$ as a mean value, and the case of working upon white paper for which *k* is ordinarily .6 to .7, I, the incident illumination should be 2 to 2.5 foot-candles, while with moderately dark colored papers having *k*

equal to, say .3, the necessary illumination would rise to 5 foot-candles. With black goods for which k is only .01 or .02 one can hardly get enough light to bring acuity and sensibility to their full values. For ordinary purposes not requiring extreme acuity a may generally be taken as 1, while in observing very fine details 2 or in very extreme cases 3 may be assumed. The surface observed acts as a secondary source of illumination, and for details small compared with the normal visual distance the law of inverse squares holds, hence the tendency to get the eyes close to the work in insufficient illumination. In weak light, say 0.1 or 0.2 foot-candle variations of shade are perceived only with difficulty and one finds himself in the condition of the patient already mentioned who stumbled about because obstacles not strongly contrasted were invisible to him. At 0.5 foot-candle conditions are very greatly improved and useful illumination begins and above 1 foot-candle they may be considered normal, unless close detail is concerned, in which case more light is of some assistance. But the controlling factor in practical illumination is k, which varies widely with the luminosity of the colors concerned, producing apparent color relations which entirely mask the real ones already described.

Given, therefore, the general kind of work which is to be done under artificial light and one can reckon from general physiological and physical data the approximate intensity of illumination required. The lowest permissible illumination is, of course, for coarse work on approximately white objects, the highest for close discrimination of detail and shading in dark objects.

For very weak and very bright illumination the effect of pupillary diameter must be taken into account. So far as objects in the visible field are concerned there is every reason for keeping the illumination received from them quite near to the critical amount a, and so long as this is done the pupillary diameter, so far as these objects are concerned, remains reasonably constant.

The iris diaphragm of the eye responds by reflex action to light and other stimuli, varying in diameter from hardly more than a point in very intense light to a width in complete darkness so great that the iris actually retreats under the margin of the cornea. Ordinarily the aperture is such that the eye is working at f.5 to f.6. In strong light the aperture may fall to f.20 or beyond, and in very dark light it may rise to f.3 or thereabouts. Obviously the intensity of the image varies accordingly. If a bright light causes the pupil to contract abnormally the illumination available from objects in the field of vision is cut down and the normal sensibility of the eye may be greatly reduced.

Suppose for instance an eye receiving 1 foot-candle at its normal pupillary diameter, in such case not far

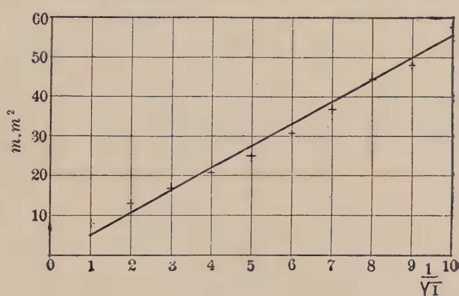
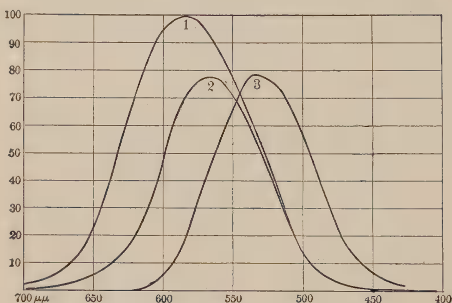


FIG. 2.

from 4 mm. Let now a light enter the field of vision bright enough to contract the pupil to 2 mm., and the effect is the same so far as the general field is concerned, as if the available illumination were cut down to 0.25 foot-candle, which a glance at Fig. 1 shows to be too low for decent seeing. Hence, the importance of keeping bright radiants out of the field of vision.

The actual relation between pupillary aperture and intensity of illumination has been investigated with somewhat various results, much depending on the state of adaptation of the eye. In examining the classical experiments of Lambert on this subject a simple approximate relation appeared between

the area of the pupil and the illumination, to wit, that the former varied with the reciprocal of the square root of the latter. Fig. 2 shows these quantities duly plotted, and the approximate linear relation is at once apparent. Hence, if we take a quantity U proportional to the illumination which reaches the retina, as the criterion of visual usefulness, then, again approximately $U = K\sqrt{I}$, which furnishes another cogent argument against trying to force the illumination too high. It is probable that the pupillary aperture is affected by the intrinsic brilliancy of the source as well as the illumination from it, but the exact relation remains undefined. This much



1. Normal. 2. Red Blind. 3. Normal at I=0.060 f.c.

FIG. 3.

is certain that a light of too high intensity or intrinsic brilliancy within the field of vision tends to defeat its own purpose by automatically stopping down the iris. This is quite apart from the well-known and serious effect of such lights in causing retinal irritation, to which the loss of many an eye may be attributed.

Any violent contrast in the field of vision is objectionable for the same reason, in less degree, so that if conditions are such as to require powerful illumination in a part of the field a very bright background in the rest of the field should be avoided, it being preferable to have there merely enough light to avoid excessive contrasts.

As most objects are colored the relative luminosities of various colors are important considerations in illumination. That the eye is affected by various colors in very different degrees is well known, and the fact is responsible not only for great difficulties in photometry, but also for serious limitations on the possible efficiency of illuminants. Fig. 3 shows several luminosity curves from the experiments of Abney. Curve 1 is that for the normal human eye taken with fairly bright light. It has a strong maximum in the yellow of the spectrum, while in the scarlet on the one hand and the full green on the other the apparent luminosity has fallen to half the maximum. In the deep crimson and the blue respectively, it is below a quarter and rapidly falling. While the luminous part of the spectrum lies mainly between wave-lengths 700 mm. and 400 mm. the effective part of it lies between w.l. 630 and 530. Energy outside these limits is for the most part wasted so far as vision is concerned.

At first sight, therefore, the eye would seem to be very inefficiently organized. Such, however, is not the case for the eye has been evolved not for artificial light, but to meet the exigencies of natural light, and its point of maximum luminosity falls very near to the point of maximum energy of the solar light, in fact, between that and the maximum energy point for skylight, so that the adjustment of the sensibility for natural conditions is excellent.

Moreover, were it not for the adjustment of the eye for a sharp maximum of sensibility, we should be totally unable to see clearly on account of the effect of chromatic aberration. When the eye is accommodated for yellow light images due to deep red and deep blue light are badly out of focus and were they comparable in brightness to the yellow image, near vision would be very indistinct, and aside from this we should lose much of the contrast which helps to render objects visible.

As was long ago noted by Purkinje and Dove, the relative luminosity of different colors is greatly affected by the absolute intensity of the illumina-

tion, a fact at once curious in itself and in photometry very troublesome. Curve 3 of Fig. 3 shows the relative luminosities for white light of an intensity of about 0.066 foot-candle. Its maximum lies in the full green instead of the yellow and the luminosity for yellow and red is very low. To be stricty comparable to Curve 1 it should be plotted with the same maximum, but its shape plainly shows that in light of so low intensity, the normal eye is red blind. Curve 2 shows the luminosities in an actual case of color blindness. Red blindness varies in amount, but no case is so severe as that of the normal eye in weak light.

The comparison of colored lights involves this phenomenon to a very serious extent, and in particular all extinction methods are vitiated by it save when used merely for the comparison of lights of similar color or for the actual measurement of very low intensities.

In fact, any photometric device which can be used on colored lights with coherent results by both the normal and the color-blind, owes its apparent efficacy to disregard of part of the spectrum generally useful.

The matter is referred to here mainly on account of its bearing on the recent theory of rod and cone vision. As is well-known, the active layer of the retina is built up with a velvet-like pile of rods and cones, the latter being most numerous and closely packed about the fovea, and the former predominating in the peripheral regions, in which the color sense is weak or absent. According to the present view the cones are modified for color perception at some loss of ultimate sensitiveness, as in the case of a photographic plate specialized for orthochromatic photography. At low intensities, say 0.1 foot-candle and below, cone-vision rapidly goes out of business, leaving rod-vision greatly predominating, as in Curve 3. Perhaps, the rods are relics of a primæval eye, of which the central area has gradually been modified as an aid to the color perception so useful in determining contrasts. At all events the theory gives a very consistent explanation of the Purkinje effect.

Now in using artificial illuminants the real usefulness of the light evidently depends upon the amount of energy which falls within that part of the visible spectrum to which the eye is reasonably sensitive. In fact, the photometric principle laid down by Crova, of comparing lights by their respective components in the neighborhood or 590 mm. wave-length had much to recommend it in dealing with sources which give a continuous spectrum.

The position of the energy maximum in the spectrum of an incan-

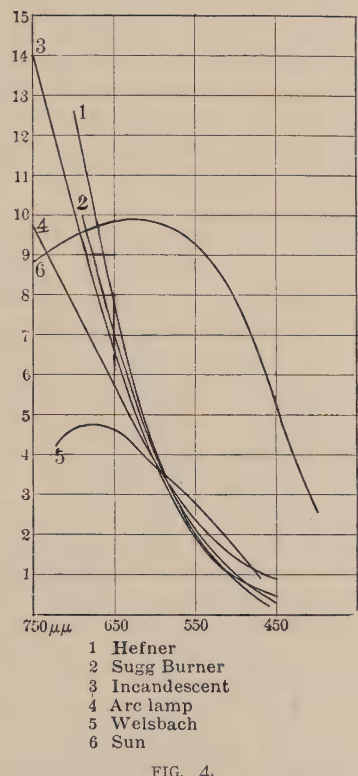


FIG. 4.

descent body is a function of the temperature, and unfortunately the temperatures available in flames, incandescent lamps and so forth are too low, say 1800° to 2200° absolute to place this maximum where it will do the most good. In fact, to put the

maximum where it ought to be requires the solar temperature itself.

Fig. 4, from the researches of Nichols, gives with arbitrary ordinates the distribution of energy in the visible part of the spectrum for various familiar sources of light. The first three curves are for ordinary incandescent solids and bear a striking resemblance to each other. Curve 4 from the electric arc shows relatively more blue and less red than the others, thus corresponding to its higher temperature. Curve 5, from a Welsbach mantle, shows a considerable departure from the distribution of the normal incandescent body, due not to enhanced temperature, but to powerfully selective radiation. It indicates a very high luminous efficiency, since the maximum lies within the visible spectrum. Curve 6 is the solar radiation, which is from a temperature so enormous that the maximum is pushed up into the orange. Were one sure that the radiation is quite non-selective a pretty close value for the solar temperature could be obtained. As it is, it is only safe to say that the temperature is probably between 5000° and 6000°.

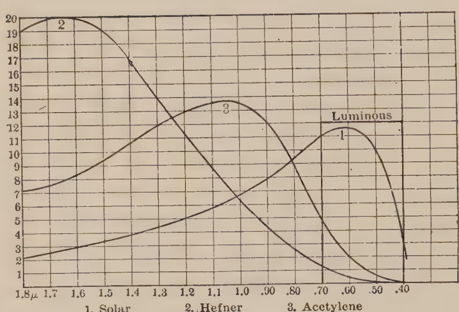


FIG. 5.

Now these curves are, so to speak, the mere fag-ends of the total energy curves. Fig. 5 shows their relation to the whole radiation. Curve 1 shows the immense advantage in efficiency of the solar radiation. All ordinary illuminants give curves lying between 2, the Hefner lamp, and 3, the acetylene flame, which is not far from the result given by the arc, the only artificial light of higher temperature.

The efficiency of an illuminant in the sense in which the expression is ordinarily used is the ratio between the luminous energy and the total energy. In this estimate the luminous spectrum is commonly taken as beginning at w.l. 760 mm. All of it that is good for anything, however, lies practically between the limits shown on Fig. 5.

The flaming arc is the most efficient illuminant yet found, and M. Blondel has been able to obtain from it a duty in the vicinity of 0.1 watt per mean spherical candle, due to the very high luminosity of the two calcium fluoride bands near to w.l. 600 mm. But the light has a large color error which can be corrected only by a considerable sacrifice of efficiency. Undoubtedly, a discontinuous spectrum gives the best chance for high efficiency, but only at the cost of serious color errors. Even if one could obtain a discontinuous spectrum of the three primary rays only, it would be at a sacrifice, and there would be some doubt of its value as an illuminant on account of chromatic aberration in the eye.

Could one steal the fire-fly's secret, the result would be, if Langley's experiments correctly represent it, a light of high efficiency it is true, but of about the color of a superannuated Welsbach. From all appearances, it will be extremely difficult to do much better than a duty of 0.5 watt per candle with an illuminant of reasonably good color quality.

DISCUSSION OF THE PAPERS ON "A METHOD OF STREET LIGHTING BY INCANDESCENT LAMPS," BY UNDERWOOD AND LANSINGH, AND "LIGHTING OF STREETS BY THE INCANDESCENT MANTLE SYSTEM," BY F. V. WESTERMAIER, AT THE NEW YORK MEETING, MAY 17.

Mr. J. T. Cowling:—It seems almost disloyal for any electric light man to say aught against the arc lamp, which has held first place so long in lighting public streets, but there is no denying the fact that there seems to be a tendency toward smaller lighting units. Invariably, though, this can

be traced to considerations of economy. Some time ago there was considerable dissatisfaction in one of the towns lighted by the company I represent, and among other things there was much criticism of the arc lamps, and the statement was made that they created such a glare in their immediate vicinity that it only tended to intensify the gloom beyond their sphere of usefulness. There was just cause for complaint, as many of the arc lamps were placed 1,000 to 1,500 feet apart. Under such conditions drivers were in constant danger of collision. The attention of the authorities was called to this and more arc lights recommended to fill in the dark places. The town authorities stated that the light appropriation was insufficient and the only way to secure more lights would be to reduce the rate. As the rate was already as low as it could be made, consistent with good service, incandescent lamps were recommended to fill up the gaps. This proposition was met with uncomplimentary remarks about tallows dips, lightning bugs, lemons on a stick, etc. Yet in spite of bitter opposition, a number of 25-c.p. series incandescent lamps, with up-to-date fixtures, etc., were installed 240 feet apart, and the street was so well lighted that the authorities contracted for lighting the town throughout with 25-c.p. incandescent lights with the exception of a score or more of arc lamps on the principal business street.

Some time later the lighting company went through a similar experience in a town eight or ten miles away, but in both instances the arc lights were replaced, not because they were unsuited to the service, but because they had been improperly located and the municipal authorities lacked the funds requisite to complete the ideal street lighting system they had planned.

I believe the arc light is destined to hold its place for years to come in lighting the principal streets of cities and towns, but in the outlying districts and in the smaller municipalities there is a good field for the exploitation of smaller units. Owing to the unsatisfactory service of the older systems of incandescent street lighting, with crude makeshift fixtures in many cases, this field was occupied largely by gas and gasoline lamps, but the modern series incandescent systems give better street lighting for suburban districts at a minimum cost.

In the Los Angeles system described in Messrs. Underwood and Lansingh's interesting paper, the consumption of energy equals 1,320 watts per 100 feet. Since a city street can be well lighted with arc lamps with less than one-fifth this energy, one is led to regard this system more as an artistic electrical display to advertise a certain section than as a method of street lighting.

To illustrate the wide range of possibilities with incandescent street lighting, I desire to say that there is a Broadway in this part of the country (needless to say it is not in New York City), which is lighted for a stretch of nine or ten miles along the Hudson River with incandescent lamps requiring 42 watts per 100 feet, and this system of lighting suburban districts has proven very satisfactory to the various municipalites and to the company furnishing the current. Throughout Westchester County there are upwards of 3,000 of these lamps in use, of 25-c.p. each, located about 240 feet apart and placed on brackets which project the lamps about four feet beyond the curb, thus doing away with the shadows so noticeable in lamps placed inside the curb and in line with shade trees.

Unfortunately, in dealing with street lighting problems the smaller municipalities regard the question of cost as of more importance than the quantity or quality of light, and even among the larger municipalities there seems to be a growing disposition to keep down the cost of street lighting in suburban districts through the adoption of smaller units, and it behooves the central-station man to encourage the lighting of such districts with incandescent lamps in order to meet gas competition. The street lighting department of an electric lighting company is an important one and well worth the serious consideration of that growing specialist—the illuminating engineer.

Mr. F. V. Westermaier:—As far as the distribution of light is concerned, I cannot agree with those gentlemen that the Welsbach incandescent lamp only gives light equivalent to a 25-c.p. incandescent electric lamp. Mr. Hopkins, of New Haven, who has been a student more along gas lines, probably, than electrical lines, but is a conscientious student and a man whose tests are unbiased, has made a series of observations with different styles of lamps, and took as his basis the distance he could go away from an ordinary lamp and read a clipping. He plotted curves showing the distances he could walk away from the different lamps tested and still read his clipping. The distance at which he could distinctly read these clippings, if I remember rightly, was something like 125 feet away from an ordinary Welsbach incandescent gas lamp, and from the Nernst lamps and the incandescent electric lamps the distance at which the clipping could be read was not half that. I claim also that the incandescent gas system of lighting is more efficient than the majority of incandescent electric systems, from the fact that the diffusion is more below the horizontal than is generally thought. By actual measurement on a radial photometer, it was found that the maximum illumination is along a line 10 degrees below the horizontal. Therefore, if you place the lamp high enough we can figure out the illumination from which we get the best efficiency. As to the percentage of light

generated above the horizontal, I do not know exactly what this is, but it is very small in comparison with the amount of light diffused horizontally or almost horizontally—mainly in a direction 10 degrees below the horizontal. I thus think that incandescent gas street light is going to hold its own and we are always working to produce better lamps, working hand in hand with the manufacturers of gas and looking to his interests as well as our own, and on the whole we are producing results.

Mr. W. T. Morrison:—I would like to make a few remarks offhand in regard to the subject under consideration. We have two districts in the Bronx which have a large number of incandescent electric lamps, one having about 600 and the other 400. We had at one time, about five years ago, considerable trouble in maintaining satisfactory service in competition with the local gas lamps in those districts. We found that considerable improvement could be made by selecting lamps of different amperages. In manufacturing lamps, you know it is impossible to make all the lamps at the exact amperages you want, and the manufacturers informed us if we could take a variation in amperes we would get much better lamps and better results. We now have consented to this and have found a much better effect, and got much better life; and by keeping close track of each lamp and testing a number of them for candle-power after they had been out, we can keep the average candle-power in all cases, even after they had been out for some time, above twenty, and even above twenty-five very often. By these methods and close inspection and cleaning of the lamps and the shades, we improved the service very much in those districts, and the lamps gave very good satisfaction.

The paper on the method of street lighting by incandescent lamps was very interesting to me. I noticed, however, that the liability to breakage is stated to be very much less by arranging the lamps to point upward instead of downward, which "protects the passerby from falling pieces of glass." We have throughout New York City and the Bronx and Yonkers districts a great number of lamps, both for city and commercial customers, over the sidewalks, and we have found practically no trouble from this cause. I think that the downward arrangement would be much preferable and there would be no difficulty from the breaking of glass and the glass falling and causing any legal troubles. In another paragraph it is stated: "All lights burn from dark until midnight, after which hour the lamps on two of the four posts at corners of the street are turned off." That apparently leaves only two lamps for each block, and as the paper states that the blocks are 600 feet long, that would leave only two lamps diagonally opposite at the corners for every six hundred feet. It seems to me that in the districts, which evidently are well built up and with well-to-do residents to sustain a lighting system of the kind mentioned, the light given by these two lamps would be insufficient after 12 o'clock. The amount of energy consumed would only be warranted by a very profitable business center, it seems to me. In New York we have in our outlying districts, say from above the Harlem River to Tremont, which is 177th street—a distance of about 18,000 feet—72 series alternating arc lamps of 7.5 amperes; this gives us only 2 k.w. per 1,000 feet on an average, whereas figured out on the basis laid out in this paper there would be required about 26.5 k.w. per 1,000 feet on an average. This would be very expensive with respect to current, particularly as it would be necessary to keep up the illumination after midnight. In the downtown districts in this city, Fifth avenue, for instance, which is very well-lighted and often pointed to as a good example of distributions of light, there are two 3.5-ampere direct current lamps on a post from 59th to 79th streets on Madison avenue, and from 8th to 79th street on Fifth avenue. In these localities there are about 206 posts, with two lamps on each post, and the watts per post are about 780, which give only 6.65 watts per 1,000 feet against 26.5 in the scheme for incandescent light described, which shows that there was a good deal of room for improvement in the efficiency. There is no doubt that the system leads to a very handsome appearance, as the posts are fine; but there is a large number of posts, too many, and too many small incandescent units, it appears to me, and the light being distributed upward and somewhat shaded in some cases by the other round globes, the system is not efficient. Take, for instance, the series system just spoken of in the outlying districts of this city; the watts per 1,000 feet are only .85 as against 26.5 watts in this incandescent system and against 2 in the Bronx district for Third avenue, which is everywhere built up with stores, and, as I have already said, 6.6 watts in the Fifth avenue district.

Mr. J. W. Bowles:—The general subject of street lighting is of particular interest to us, the Boston Edison Company, at the present time, as it is one to which we have given a considerable amount of attention, recognizing the field for improvement in this line of lighting. Until within the past two years series incandescent street lighting did not concern us very widely, but in that time, the last two years, through the taking into the system of a considerable number of suburban towns, we are now operating in the vicinity of 6,000 incandescent street lights in 25 and 32-c.p. units. We have felt the competition of the Welsbach system of lighting, and the improvement which has been brought out in that line has given us a close shave in a few

cases, although I am glad to say we have, generally speaking, held our own very well. The method of incandescent lighting, as generally practiced, must certainly be recognized as old-fashioned and in no way up to date;—the old "gooseneck," while having the advantage of simplicity and cheapness, has little else to recommend it. The enameled reflector makes an excellent watershed, but so far as being a reflector, there is little to be said in its favor. The whole subject is one which we are trying to study with a good deal of care. The fixture and bracket, and whether to mount them on existing poles or on poles of their own, and the reflector proposition—these are certainly two problems warranting very close consideration and attention. By all who are interested in that line of lighting the 6.6-ampere lamp is a generally accepted standard, on account of there being more or less arc lighting in the centers of towns in connection with incandescent lighting, and we are practically obliged to hold to what has been spoken of as the higher current—currents higher than we probably should hold to, if it were not for the arc light feature.

The paper describing the system in Los Angeles is certainly very interesting, and it is easy to understand how the lighting effect and the artistic effect must be very interesting; but the amount of energy per foot of street is certainly very unusual. The system is one which we would be glad to see introduced from the standpoint of selling current, if we felt we could sell current on such a basis. I have noted with some interest the method of controlling the lights along the Los Angeles streets. I assume, of course, this lighting is all from the multiple low-tension mains, supplying at the same time commercial service.

Mr. T. J. Litle, Jr.:—In regard to the candle-power of a Welsbach mantle, it is a very conservative figure to place 20 candles per cu. ft. of gas as the actual light given by the mantle; in other words, on the new burners which are now being used and where the controller just under the burner is set for 3 feet of gas, it is perfectly possible to get 60 candles, and it frequently runs over that; and unless the gas is very poor, this will always be the case. I do not think I know of a place where it runs below. That is an actual reading and not merely an advertised candle-power. You have probably seen the candle-powers of mantle lamps given as high as, say, from 100 to 300 candles, but as a matter of fact a good, conservative, safe basis is about 20 candles per cubic foot of gas consumed. With the ordinary house burner we burn a little more gas than that, say 4 to 5 feet, but that same figure will apply. When I say that I do not mean the measured candle-power of the new mantle, because when we measure the candle-power of the new mantle we get considerably more than that; but that is a good average candle-power throughout the life of the mantle, and I have seen an efficiency of 25 candles per foot on new mantles. That depends on the mantle, on the structure of the mantle, and the length of life. With the newer high grade of mantles the candle-power life has been considerably increased. An incandescent mantle, much like an incandescent electric lamp, can be made good or poor. The process employed in the cheap mantles is to take a cotton web, and give it a very light impregnation; then almost all the fluid is squeezed out in the wringers, and consequently you have a very fragile mass depending from the loop, which can be compared with the cheap incandescent lamp.

Speaking of reflectors for street lighting, I do not see any particular advantage in using the reflector. What should be desired is a rather uniform illumination along the street. I do not think bright spots of light are good, and consequently the reflectors that I have seen throughout the country could hardly be called efficient for the illumination of the street. I was in Toronto the other night, and I saw some reflectors there on the gas lamps which were really reflectors for street lighting, as they threw the light up and down the street. There is more reason in this than in case of the reflector throwing the light horizontally.

In incandescent mantle lighting, as I said here at another meeting, there has been a change during the last year in the color and character of the mantle. The old mantles, which you still see in large numbers and which give that greenish-white light that was so objectionable, are gradually disappearing, and if you will observe, you will find they are gradually being replaced by what we call the mellow white lights, which are richer in the reds and oranges. These mantles are more satisfactory. It is very hard, however, to educate the public to that way of looking at the proposition. The mantles made in that way are more durable, are tougher and also maintain their candle-power a great deal longer. At the end of 1,000 hours, one of these mantles will probably measure 75 per cent. of the initial candle-power. That is a good average—a loss of 25 per cent. in 1,000 hours.

Mr. C. A. Barton:—I was very much interested in Mr. Westermaier's remark about the test by the gentleman in New Haven. Such information is only valuable when the conditions are fully given. It is quite possible that this gentleman might have made these tests with the Welsbach gas mantle, but before the data have any value whatever, you must know the pressure conditions, the condition of the glassware, the height of the lamp, etc. All of these are factors, so that a statement like that made has little value unless the conditions are

standard for each particular unit considered.

I was also interested in Mr. Litle's remarks about the candle-power of the Welsbach mantle. There, too, he neglects to state the pressure. We must have the pressure, as the light is a function of that. Any statement about the comparisons of lamps should always be accompanied by a statement as to conditions. A great many people do not bear that in mind—even engineers—and they thus receive erroneous impressions as to different illuminants; we as engineers always ought to be careful to state the conditions of tests.

Mr. W. D'A. Ryan:—I think the Los Angeles situation is very interesting, and perhaps we can better realize the extravagance of the illumination when we consider that ordinary street lighting with lamps placed from 250 to 500 feet apart, ordinary arcs, run from 1 to 2 watts per street foot. I think that Fifth avenue runs to about 3 watts, but that is a very good light. Buffalo and a few other places come up around 5, but when you jump to 25 or 30, it is a very long leap.

Speaking of the distribution from reflectors for incandescent lighting, there is no question that the present street reflector is of very little value except as a watershed. As to the question of the candle-power of the gas mantle as compared with the incandescent lamp, if the mantle is just the least bit tapered, the maximum will come about 10 degrees above the horizontal. We are making a very extensive series of tests, comparing street incandescent with gas mantles. I cannot now state definitely just what the relation is between the two, but we are measuring them in in various cities in service under practical conditions. I can say this, without being very definite, that between the 60-c.p. mantle in its ability to throw light down the street, will be the equivalent to between the 25 and 30-c.p. incandescent electric.

Mr. Victor A. Rettich:—I wish to call attention to one of the main streets of New York City as an example of what I consider fine illumination—Manhattan avenue, which is lighted entirely by gas. I do not know the distance between the lights. I would like all of the gentlemen here who have not seen the lights on Manhattan avenue to go up there and inspect them. I would like to ask Mr. Westermaier, first of all, the approximate life of the mantles; second, the duration of the wires—whether or not the wire supports do not burn out long before the life of the mantle is ended; third, whether the use of the metal chimney increases the candle-power of the mante, or whether it is simply used as a means of protection while the globes are being cleaned; and, fourth, whether the use of anti-vibrators has been entirely abandoned. I would also ask whether any serious objections to the use of clear glass chimneys has arisen, in so far as increased candle-power can be obtained with but a slight increase of gas consumption.

Mr. Westermaier:—The enameled chimney which we suspend from our lamp does increase the draught in the mantle. As far as the glass chimney is concerned, we use so little glass that a chimney does not necessarily increase to a great extent the efficiency of the mantle itself. There are a number of objections to the use of a chimney on a street lamp, but there are also a number of advantages to be gained by the use of a chimney. In the first place, by putting a glass chimney on a street lamp, you increase the protection against draughts. Where the pressure is low, the chimney is indispensable. Where we have to deal with pressures under two inches we cannot get along without chimneys and produce good results. Of course, the chimney requires considerable care to keep it clean. We insist it shall be kept clean, and that entails additional expense.

As to the average life of the mantle, it depends a great deal on the way the pole is set into the pavement, and it is very hard to give an estimate of the average life of the mantle. As to the burning out of the wire supports, we are now using a nickel wire support which is giving us very good service. We used to have a great deal of trouble with the iron supports from an iron oxide forming on the top of the mantle, which would in time grow so large that it would cause a breakage; but we do not have any trouble with the nickel wire supports. The use of chimneys abroad I think is mostly in connection with high candle-power lamps. They carry lower pressures over there than we do here. We use chimneys almost universally where the pressure is low.

Mr. Litle:—Mr. Barton asked whether the pressures were considered when the test was made to which I referred. The standard pressure in laboratory tests of incandescent gas lamps is 2 inches water pressure, a little over an ounce. We took that standard, as you would the standard of 110 volts in electric lamps, and usually we make no mention of the pressure in offhand remarks. Of course, with increased pressure we can get increased efficiency. There are lots of devices for increasing the efficiency of incandescent lamps.

Mr. Barton:—My remarks referred to Mr. Westermaier's statement of curves plotted by the gentleman from New Haven. They are of no value unless that gentleman had control of the pressure of the electric current and the Welsbach current. They would not be comparable unless the pressure was standard, and the pressure properly under control.

Mr. Westermaier:—These tests were made during the competition for the street lighting in New Haven; there were certain competitive bids presented and Mr. Hop-

kins, who made the tests, is superintendent of lights in New Haven.

Mr. John Campbell:—In regard to the tests referred to, which were made by Mr. Hopkins, is not the whole question involved in the further question of the use of the eyes in the photometer? You hear in a discussion of street lighting a great deal said regarding the candle-power, from either the gas or incandescent electric light, when as a matter of fact it is not candle-power we are after, but the area to be lighted; and the area for street lighting is different from that for interior illumination. It is well enough to speak of candle-feet in interior illumination, but it seems to me in street illumination it is the case, rather, of measurement of area; some more accurate means of measurement is desirable than simply using a newspaper clipping and the eye, for the gentleman who made the test might have happened to have eyes different from those of some one else, and another person making the same tests under the same conditions, as far as the eye is concerned, might arrive at entirely different results. This society should take up the question of street lighting; in my experience with different municipal committees, I found that there is not a great amount of accurate data available. There are certain standard conditions which this society should work out and have adopted as standards in street lighting measurements.

President Marks:—I think the remarks made by Mr. Campbell with reference to the use of the photometer in the measurement of street illumination is very apt. After all, we cannot take a newspaper and assume that because one man can see the print better at a certain distance with one light than he can with another light, that one light is stronger or weaker than the other, so far as its value in illuminating the street is concerned. This is a very old question. The rays of the spectrum, starting from the red and going to the violet, do not affect the photometric measurement in proportion to their strength. The yellow rays of the spectrum enable us to read the newspaper better than the shorter wave lengths at the violet end of the spectrum, whereas in many cases, particularly in suburban illumination, we may want some rays corresponding to the shorter end of the spectrum. If it comes to a question of bringing out the natural color of the objects, there is no doubt you need the waves at the violet end of the spectrum and not those at the yellow end. A study of this subject is one that I certainly hope the society will go into. As Mr. Campbell has remarked, there is a notable lack of available data bearing on street lighting, and now that we have opened the subject, I hope that this fall or winter we shall hear from those of you who care to give us some further data on the subject.

Mr. Rettich:—Some well-known engineers on the other side made certain experiments in Glasgow and Edinburgh to find out the actual candle-power in the street at the height of a person's face. The results of their investigations are fully recorded in the *Journal of Gas Lighting*, but the exact date I do not remember.

Mr. E. L. Elliott:—The inefficiency of the street lighting by incandescent lamps in Los Angeles has been dwelt on somewhat. If you will look at the figures in the paper, the cause of it will be very apparent. The designer here has evidently designed a beautiful pedestal and incidentally put some lamps and globes on it. So far as the illumination is concerned, it has all the faults it could have, I think. In the first place, there is a very heavy support, with a projecting saucer, under each of the lamps, with the lamps clustered so that they are in the way of one another, and are covered with opal globes. The mere fact of their being clustered is illogical from the point of view of the illuminating engineer. That is perhaps to be traced to the effect of the use of the arc, and the various sins against illuminating engineering for which the electric arc is responsible are many. The chief of these is the tendency which has existed ever since its advent to use very powerful units, units of high total candle-power, and where that is impossible with a single source of light, to cluster the units. To illustrate the point in mind, I will refer to Manhattan avenue, which Mr. Rettich speaks of as being well illuminated, as it is. What would be the effect if you took seven incandescent lamps and stuck them all together on one post and took out six of the intervening posts? That is what has been done here. The effect is handsome; if they merely wanted a handsome effect they have got it. But when it comes to illumination, if they would distribute the lamps the effective illumination would be much better. There is a certain air of festivity given by a number of lamps in clusters, which high-power single lamps do not give. The boulevards of Paris are lighted with strings of flat burners, but there are so many that the effect is that of a well-lighted street.

As to reflectors, it is not desirable in street lighting to obscure the source of light entirely, because one should not neglect, especially in incandescent street lighting, what may be called the beacon light effects. Showing the light itself is a good part of the lighting; otherwise it would be possible to construct a reflector to give almost any illumination on the street you please.

Mr. F. W. Willcox:—I am sorry that the discussion has not brought out to-night from those who are familiar with the practical end of this work, interesting details as to their experience in the sizes of lamps, height of lamps, distances between lamps,

etc., necessary for street illumination. In urban districts, suburban roads, etc. I want to endorse Mr. Elliott's comments on the lighting of Los Angeles. Of course, from a lamp man's standpoint, that is a fine thing. There never was a more extravagant street illumination from incandescent lighting, using so many lamps, and therefore we perhaps ought to endorse it; but I am very much surprised at the character of the installation and the unnecessary extravagance in the use of lamps. The use of six 32-c.p. lamps massed on one pole is very bad, not only from the lighting standpoint, but from the lamp standpoint. The loss of light due to the heating effect inside of the clusters is very bad and must consume many lamps. Furthermore, the use of ground-glass globes must entail a loss of from 20 to 25 per cent. of light, reducing materially the efficiency of the lamps; and it seems so strange that electric lighting, which we all know is very convenient for distribution—simply a wire connection to a pole and you have your light—should be from lamps massed at points instead of distributed along the streets. There is some excuse for gas lighting where connections have to be made to pipes, for not distributing very frequently, but with incandescent lights there can be no such excuse. The very ease and inexpensiveness with which the lights can be distributed at frequent intervals should lead to their use that way instead of massing them as described in the paper.

President Marks:—In connection with the proposition to collected data on the subject of street lighting, it occurs to me it might be a good idea to appoint a committee to investigate the subject of street lighting and to gather reliable data in connection therewith; this committee to serve for a certain period of time and report to this society the results of their deliberations in a regular committee report.

Mr. A. A. Pope:—I want to call attention to the fact that we have just such a system of street lighting as that of Los Angeles within two blocks of this building. I think almost the same identical fixtures illustrated in the paper are in front of the Hotel Imperial, spaced about 25 feet apart, and any one interested can see those lamps in operation this evening.

President Marks:—You will find the same idea in the arrangement in front of the Hotel Astor.

The meeting then adjourned.

DISCUSSION OF THE SAME PAPERS BEFORE THE NEW ENGLAND SECTION.

Mr. Cowles:—The papers before us tonight are of especial interest to those who have to do with the question of illuminating our streets. The question is of especial interest to the men of the Edison Company just now. Until within about two years, the subject of street incandescent lighting was not of great moment to us, but during the last few years, due to suburban expansion, we have got so that we are operating in the vicinity of 6,000 incandescent street lights, and the question becomes one of marked importance to us. We are now studying the problem with especial reference to possible improvement in efficiency and artistic results. While it is to be presumed, of course, that it is light and illumination that the town is paying for and therefore demands, the question of artistic appearance has been brought more and more to the front, and of course in this respect we must admit that the gas interests have gone somewhat in advance of the electric. We have been quite interested of late in a comparison between the candle-power results of the gas arcs and electrics. We have found that in those places where the gas lamps are maintained at the point of highest efficiency, where the mantles are kept in the most up to date condition and the lamps kept regulated to the best results, it is quite possible to obtain practically the 60 candle-power claimed; but otherwise, when we take the gas lamps as we find them throughout a town, measuring not only the few lamps at the corners of the principal streets which have been kept up and received attendance far in excess of the average lamps, but also those on the side streets in less important locations as well, we find that the average figures take a very decided drop from the 60 candle-power that we hear about. Tests have shown that the average results of the gas-mantle lamps are very close to the average results of incandescent lighting, using 25 to 32-c.p. lamps. Of course we have felt the competition of gas, but I am glad to say that we have almost without exception held our own in a very satisfactory manner. The question of units—the most desirable candle-power for use for street illumination—is one which is dependent somewhat upon local conditions as well as upon the amount of money which the town or city feels able to appropriate. It goes without saying that better results are obtained with a larger number of small units than with a lesser number of larger units; and the tendency in our case has been toward the 25-c.p. lamp, although we use a 32-candle-power in many places. The 20-c.p. lamp is not common except in a few of the smallest places, and it seems to us that 25 candle-power is as low as any from which good results can be obtained. The system described in Los Angeles is very interesting, and we can appreciate must produce very artistic results; but from an electrical or illuminating engineering standpoint the system is, we might say, absurd. To think of clustering 1,520 watts in each pole—the amount of energy equivalent to an arc lamp

at every 25 feet—is extravagant in the extreme. Those of us in the central station business would doubtless be very glad to sell current on that basis, but I am afraid there are very few places in the East where we could expect to dispose of current in such liberal quantities. The clustering of six 32-c.p. lamps inside of one globe, with the resulting confinement of heat and therefore great reduction in the life of the lamps, together with the reduced light due to the opal globes, is certainly a remarkable procedure from an engineering standpoint. The clustering of the lamps in such a way as to make more or less interference—that is interference of the lamps with each other in the shape of shadows—is surprising; and while of course the result must be artistically pleasing and so far as light is concerned, cannot help being satisfactory, yet the system certainly does not present good practice and is not one that could generally be recommended—certainly not in this part of the country. We are unfortunate in not having Mr. Wilcox's paper before us tonight. Mr. Wilcox's paper, as presented at the New York meeting, was a very interesting and optimistic forecast of the good results to be obtained from the graphetized filament of which we are hearing so much as applied to the series lamp. While of course that lamp is very young and the data of results obtained from the lamp thus far are small and incomplete, yet the lamp does promise to produce marked progress and advancement in economy and in efficiency of light.

Mr. Sargent:—All I can say in regard to the new lamp is that we have put 200 very recently on test, and so far have got good results. After this test is completed I can probably give you a good deal better idea of the performance of the lamps. In regard to the candle power of lamps, I think that is something that is going to be changed. We have something over 3,000 lamps in use of 25 candle power. I think that candle power has been standardized here in New England more than elsewhere. I do not think myself that it is high enough. I think the lamp that should be standardized for street lighting is the 40-c.p. lamp; for general illumination for streets it would be preferable and give better distribution. We are about to endeavor to get data on street lamps. I have been having several photographs taken of incandescents in street lighting in other towns and also of gas street lighting, and for further information we are starting this week to have readings taken on all candle powers, 25, 30, 40 and 65-candle-power, of the new high efficiency units under commercial test in the streets in residential districts, etc., to show the different illuminations at different distances, so as to get some results of practical value. I think there is one thing we neglect and which was also neglected at Los Angeles, and that is, to get the useful light from the lamp, which is not done because they are put up at the side of the street and they give more light on the sidewalks and houses than in the middle of the street. Incandescent lamps are usually placed out on the sidewalk so that you get more light on the street; and while they are not so ornamental, I think it is preferable to have more light rather than ornamental light. We are also going to make tests on that point. I think after we get these tests completed, as I hope to by next month, that I can have considerable information to give on that point.

Mr. Sands:—I think there is one thing we have got to take middle ground on, and that is the artistic question. I think we must all admit that when it comes to the appearance of the lamp on the street, the gas people have us beat out; and in Haverhill when it came to the question of a new street lighting contract, the strongest argument put up against us was the disfigurement of the streets—that we could not furnish as ornamental a street fixture as the gas people. Now as to what Mr. Sargent says, I believe we have got to strike a middle ground somewhere and if we are going into residential street lighting we have got to design a street fixture which can be made to carry the illuminated street names and which will furnish a more artistic appearance, even if it is at the cost of a reduction in efficiency.

Mr. Barnes:—I would like you all to come to Providence and see a fixture we use there. We adopted a very ornamental bracket. Of course it cost a good deal, but we believe it is far ahead of any gas lamp that has been installed on any street. The fixture cost is about $3.50, without the reflector. They are put on every other pole, which brings them about 250 feet apart. In the towns they are from 200 to as much as 600 feet apart; but we have found that if put about 600 feet apart the space is afterward filled in by men who want a light, and the number of lamps has grown very rapidly. There is hardly a month in the year that we do not have orders for two or three hundred. We have not discovered so far that there is much profit in operating series incandescents. We run all night and the town only runs until twelve o'clock with their lights. Perhaps we established too low a price at the start.

Mr. Brown:—Something occurs to me in connection with this high efficiency lamp, and that is the maintenance of candle power. Of course, it is a well-known fact that in an incandescent lamp the candle power depreciates for several reasons. In any lamp there is also a blackening of the bulb and change in the filament. In the metalized filament series lamp, being for constant current, the current does not vary. In regard to change of composition of the

filament, that does not seem to cut very much of a figure and it is a peculiar fact in regard to this new lamp that is does not blacken. In fact I have seen some measurements quite recently of series lamps which showed a wonderful holding up of candlepower with considerable length of life. I think that is a condition that should be taken seriously into consideration with this new lamp.

Mr. Sands:—In regard to these lamps, I think the reflector part has not been given consideration. The reflector as used on incandescent street lighting is of no use at all. I know we keep ours painted white but they are of a curved nature and from eight to ten inches from the lamp and have very little effect. I think there is a great field for a new reflector that will throw upward rays at least to a horizontal, not simply down; and I believe that something is being done in that matter and should be thought of a good deal in connection with the series incandescent lamp, as the present reflector is not really ornamental or effective at all.

Mr. Brown:—There is one scheme of street lighting that has been called to our attention, though I do not wish to comment on it much either way, and that is the scheme used by the Hartford Electric Light Company. They have 40-c.p. lamps in connection with ordinary Holophane reflectors. The lamps are set at such an angle that one lamp throws a light up the street and the lamp behind it throws its light in the reverse direction. It certainly gives an immense amount of light up the middle of the street. Whether it gives too much light and has practically the effect of an arc lamp in the eyes to people driving carriages I cannot say; but it certainly to my mind shows what can be done by means of some suitable reflector of some kind. I think there is a good deal of meat in the scheme adopted by the Hartford Company.

Mr. Cowles:—The metalized filament of the General Electric Company that is being brought out is simply a metalized instead of a carbonized filament. It is identically the same in its early principles,—that is, starting with the same material practically, but is treated by different processes so that the filament, instead of being carbonized, is metalized. It took us some time to believe that the filament was a metalized filament. We were inclined to think that metalizing was something we could use in argument, but we finally had to believe that the carbon structure had been sufficiently changed as to make it partake at least of the nature of metals. The lamp put out at an efficiency of 2.7 instead of 2.5 watts, which is the efficiency point adopted for the multiple or ordinary lamps. That efficiency is subject to modifications as may be found desirable or necessary from results. They have aimed to strike a medium between the 2.5 and the 3.1 watt standard. Of course, the lamp is new and like all new developments, it does not jump into the stage of perfection at once.

Mr. Robinson:—There is one thing I would like to speak of. I have heard a great deal of praise for the Providence fixtures. I have been in Providence within three days, and there were two things that impressed me about these fixtures. The first was the proportion of the shade or the reflector to the fixture itself, and the other was the method of attachment to the pole. It did not seem to me that the design of the fixture lent itself very well to attachment to the pole. I do not speak of this in a critical way, but these are the two things that struck me—first that the shade was too small and looked like an acorn on an oak tree; and, second, that the fixture was plastered on the pole and did not set very firmly.

Mr. Barnes:—As to the attachment to the pole, of course it is put on in a very substantial manner, certainly so as to stay there. The reflector itself, I think, is larger than the regular General Electric reflector. We are using a collar on the top of it. The top part of it, which used to rust out pretty badly, we have replaced with copper.

Mr. Robinson:—I think Mr. Barnes takes my criticism a little differently from what I meant it. I spoke entirely of proportional lines. The fixture may be very firmly attached to the pole, but the design of the fixture does not lend itself so as to suggest a permanent attachment. The idea I meant to express is that something in the way of arc lamp fixtures here in the city of Boston might be well. They go out of the pole and drop over. This thing comes down and crawls around and is caught under the pole. The artistic point is what I was referring to rather than the mechanical.

Mr. Woodward:—The matter of the acorn like appearance of the reflector is really the appearance of the insulator back of the reflector, which is quite large and is really a large truncated cone, the reason of its size being originally and at present that the lamps, being operated in series on circuits of considerable length, the difference of potential at the terminals of the circuits quite high; we found more or less trouble with the lamps grounding and we use a very heavy and very thick insulator. It is possible that it has distorted somewhat the appearance of the fixture, but otherwise I am conceited enough to think it is fairly attractive. I will accept the criticism on the acorn appearance above the reflector.

Mr. Cummings:—It occurs to me that there may be something in the fact that was brought out during the last meeting with regard to the illumination of a lamp not being entirely dependent upon the candle power, but possibly may depend also on the color of the light. That possibly also applies to the fact that the incandescent

mantle lamps give very good satisfaction. Is it not possible that it is not all in the candle power—that the value of the light depends somewhat on the part of the spectrum the light appears in? There is another thing that has been brought to my attention, although I have never had a chance to look into. I notice in comparative photographs of lighting by mantle lamps and by incandescent lamps, there seems to be a wider discrepancy in the photographs than is noticed with the eye, and it occurred to me that possibly the effect on the negative film was not in proportion to the candle-power but dependent on the color of the rays.

Mr. Sargent:—I would say in regard to the photographs we have taken on street lighting, that whereas it is a well known fact that Welsbach lighting should show better illumination in the photograph than the incandescent on account of the orange rays, on 25-c.p. street lighting of the same spacing, taken the same night on two streets, the incandescent of 25 candle-power showed better illumination than the Welsbach in the photograph.

Mr. Woodward:—The comparative value of Welsbach and incandescent street lamps is very well illustrated on a foggy damp night when there is considerable suspended moisture in the atmosphere. Then the carrying power of the electric incandescent lamp assert itself; with two lamps of a given candle-power, a Welsbach and an incandescent lamp, on a foggy, damp night, the electric lamp will have much greater carrying power and give a better illumination for any given distance than the Welsbach lamp of the same candle-power.

Mr. Sargent:—I spoke of this matter of photographs only to show results where photographs are compared of incandescent lighting and Welsbach lighting, where an opinion is usually formed from photographs that one is better than the other. I was very much surprised to see the results we got, but I would say that this was with the new lamp and with the old type of lamp we thought it was fully as good. We also have made photographs with a 50-c.p. lamp and there was no comparison at all. As I said before, the 25-c.p. incandescents were better than the Welsbach.

Mr. Campbell:—Is it not a fact, gentlemen, that in the matter of street illumination a good deal of it is ancient history. Somebody in the past has made grevious mistakes and we have been following copy ever since; and in present day illumination should we not consider the area lighted rather than the candle-power values? It should be the carrying value through fogs and different atmospheric conditions and also the even distribution of light through the streets; that is, not particularly bright spots and then running into dark spots, etc. That, unfortunately, here in New England certainly and in other places worse than New England, is characteristic of the present-day street lightng,—not that which we are coming to, but that which exists to-day here. Of course in street lighting we have the city and town portions—the residential and the business sections—to deal with. In the matter of residential lighting, in a great many cities you will find an arc light at one corner. This is very beautiful, but you get down the street a little and there is no light at all; if there is, it is a mantle burner lamp, and your eyes have been dazzled by the arc so that you can hardly get any benefit out of this; whereas if it was a smaller unit of arc and a greater number of them, there would be much better distribution, and it seems to me we would be getting nearer the true street lighting than on a candle-power basis.

Mr. Cowles:—I think that question of uniformity is most important and for that reason I cannot agree with Mr. Sargent that the 40-c.p. lamp should be standardized. I believe that a large number of small units will give better results than a small number of large units, assuming the same total candle-power. I believe that for suburban lighting far better results are to be obtained from the smaller units placed more frequently on the street. We surely have all noticed in riding and driving at night the better service from smaller units placed near together than from larger units placed at greater distances, and therefore a greater brightness in each one. I believe that results would be better, if instead of having two lamps placed on the same pole back to back with reflectors back of each lamp for throwing light in opposite directions, as at New Haven, to distribute those lights along the way at smaller distances. I do not understand just what the standard is in Providence. Of course the question of size of the pocket-book has a great deal to do with it, and, as the chairman said, we must distinguish to a certain extent between city lighting and suburban lighting.

Mr. Sargent:—In regard to the number of lamps, I agree with Mr. Cowles that the more small candle-power lamps you put in nearer together the more equal distribution of light you will get. At the same time the cost of installation and maintenance must be ascertained and has a bearing upon what is the best candle-power lamp to use. The cost of small candle-power lamps of course multiplies the installation cost. If you can cut that down one-half, that makes just so much difference and there is a point at which the thing has got to stop. That is why I said 40 candle-power. 32 might be better, but I do not think a 25 is large enough. There is another consideration, and that is the Welsbach light. We want to get a lamp that will compete with that in every way. I have seen streets lighted with 16-c.p. lamps put on opposite poles on each

side of the street. It made beautiful illumination; you could not ask for anything better; but I think the street could have been lighted at a good deal less maintenance cost and first cost and given satisfaction. In regard to location, the incandescent lamp should be out at least four feet from the sidewalk line. Residential streets do not usually have car lines, and you get enough light from the four feet out to light the sidewalk. The Welsbachs in general lighting are on a line with the curbstone. Residential streets are usually thick with trees and Welsbach lights in line with the trees cast large shadows across the street; that is one reason the distribution of lights shows up so poorly. Of course you might say that if the lights are out in the streets they will cast shadows on the sidewalk, but the sidewalk is a very narrow area compared with the street.

A Member:—I have been much interested in the remarks, and it seems to me it comes to this—how much will the one who pays for it expend—whether it be the municipality or the installing company. Nearly all of the propositions in regard to making a better lighted street have been in the line of a bracket on poles. Nothing has been said about the lighting in residential districts where such things are not possible. We have to compete with the Welsbach standards set on the streets where there must be underground lines. I would like to ask if anyone here knows of such an installation as that and how much its costs? We have heard in this paper about Los Angeles lighting, something which in a city like this is absolutely prohibitive—the poles costing $100 each and an enormous amount of copper beams used to furnish 12 amperes per pole at 110 volts. The only thing to complete the farce in my estimation was that they should have added a station man and cable manufactory. It seems like pushing a good thing, and such a thing as that is out of the question in a city like this. I am of the opinion that uniformity of light with a decent fixture is what we ought to have without costing too much. We certainly ought to do something better than stick a piece of gas pipe out with a socket on the end of it.

Mr. King:—I think that the proposition which the municipal man runs up against is perhaps a little different from what it is with the privately owned plant. My experience has been that with the municipally owned plant the limiting factor is more the station equipment than anything else. The town is willing to install a great many lights but they do not care to put in the station equipment for supplying those lights; whereas the city when lighted by a private company, makes a contract for what additional street lights it desires, and the company itself stands the installation cost. When you add to the running expense the installation cost for new lights, it makes it look a great deal larger. For example, if in one of these cities where they have a private company, the city wishes to add 10, 15 or 20 lights, they simply add to their appropriation the sum of money necessary to cover the operating of that number of lights; but where it is a municipal installation, about every time the city or town increases the plant, they will increase the number of street lights until they have the plant loaded, and then when more lights are needed they have not only got to run the lights, but put in more apparatus to supply them. I have had occasion several times to go into the town of Ipswich, which has a municipal plant. They have not an arc lamp in the entire town, which is lighted with 16-c.p. incandescents. In the main part of the town these lamps are placed on every pole, and one gets away from the more thickly settled part of the town, they go on alternate poles to the town limits, making the lights 100 feet apart approximately throughout the town. While there is no part of the town which is brilliantly lighted, for a town to drive through it is one of the best I know of, and I think if the town will stand the installation charges of the 16-c.p. lamp, two 16-c.p. lamps will be better than one 32-candle power, and that is especially true where there are a lot of trees.

Mr. Robinson:—On this question as to how much the town will spend and the question of spacing, perhaps some experience I have had might interest the Society. This town was lighted by about fifty arc lamps and its streets were very heavily shaded by maple trees. There was considerable dissatisfaction in the summer time because there was no illumination except at the street corners of principal streets. We made a proposition to replace each two arc lamps by nine 25-c.p. incandescent lamps, which was accepted. The only condition we imposed was that the installation of new lamps should be within the established lines of the company. The result was they received one incandescent lamp for each 200 feet and on outlying streets one for every 400 feet.

Mr. Campbell:—It seems to me that our discussion to-night and the New York discussion as well brought out the fact that on the actual facts in regard to this manner not only the town fathers but the central station men as well are groping in the dark trying to get the best illumination, and I think Mr. King's question was a very pertinent one as to the proper spacing, and I hope this society as a section of the parent organization, which is doing the same thing, will get together by means of a committee or otherwise, and prepare for the fall such information for our members as possible and then put that information in the hands of a committee and have it

properly checked, so that when it goes out it may be information and not simply some one man's experience but facts that can be used by our members or anyone and which cannot be disputed.

Mr. Cummings:—The thing that struck me tonight especially inasmuch as we are an engineering society, was that with one exception there has been nothing mentioned with regard to the curve of the particular lamp which is used to illuminate the streets. As is well known, the old arc lamp had a good curve for carrying wide distances because its intensity was at such an angle that the old rule of the square of the distance lent itself to that. I notice in the paper on the Los Angeles system it speaks about the great proportion of the light that went up in the air, and it is possible that by getting a curve that would carry and distribute well we could get better illumination and come within our province. Another thing which leads me to think of that is the difference to the two incandescents with the Holophane shades which reflect the light, which seems to be in the line of engineering, putting the light where we want it. Engineering is taking what we have and making the most of it, and it seems to me when we are throwing a lot of light up in the air that we are not doing that. With the old Welsbach mantle there are very few curves in regard to that lamp I have run across. Most of them show a uniform spherical candle-power and that is not true of any incandescent lamp I have seen. The Welsbach throws a good deal up in the air. The question comes up whether by the use of Holophane globes on the Welsbach we might not get more of that light where we want it, and I wondered whether the question had ever appealed to the electrical men, whether they could do something in that line for the incandescent light.

DISCUSSION OF THE PAPER ON "RESIDENCE LIGHTING," BY J. R. CRAVATH, AT THE MEETING OF THE CHICAGO SECTION, MAY 7.

Mr. John F. Gilchrist:—One of the principal things brought to mind by this paper is the great lack of properly designed fixtures. Fixtures are now made without any idea of the lighting effect to be produced, but simply for ornament. We are now at about the same stage in illumination that furniture making was at the time when William Morris began to teach the world that furniture could be at the same time comfortable, useful and artistic.

Mr. O. J. Bushnell:—The man who owns his own home can arrange electric light fixtures to suit himself, but the one who suffers most from poor illumination is the man in rented quarters. He had recently moved into a new apartment where one or two of the rooms had lighting well designed in accordance with the principles laid down by Mr. Cravath. In the kitchen, however, no electric light whatever had been provided. Upon commenting on this to the landlord he was told that it was a common thing for Chicago architects to omit electric lights in the kitchens of flats and apartment houses. He thought this a remarkable state of affairs if true.

Mr. J. R. Cravath:—The kitchen should as a rule have the best general illumination of any room in the house, because it is a work room requiring good light in a number of places. In other rooms in the house it is usually necessary to provide illumination in only one or two places, as, for example, for reading in the living room and at the dresser or over the bed in a bed room. In the kitchen there must be a good light in the whole room.

Prof. P. B. Woodworth:—In designing the illumination of some 40 residences and apartment houses, in the case of residences there was no great difficulty in providing satisfactory arrangements to suit the owners as the requirements were fairly uniform. In eight different apartments, however, there were as many different ideas as to the uses to which the various rooms were to be put, and consequently no lighting arrangements suited to one apartment could be duplicated in another. In the lighting of small bed rooms, where only one outlet is available, there was no way out of the difficulty but to use a portable bracket which could be hung on the wall in various parts of the room where it was needed.

Mr. Cravath:—I agree with what Prof. Woodworth said about the usefulness of the portable wall bracket in bed room lighting. Unfortunately there are few satisfactory portable wall brackets to be found on the market at present. This is a matter to which fixture dealers might well give some attention.

Mr. S. M. Bushnell:—There is a tendency now away from the old idea of keeping down expenses as much as possible with electric lights, since the cost to the consumer is being constantly reduced. It will be the province of such an organization as this to arouse demand for better illuminating arrangements. In the old days it was difficult to get a hotel keeper to consent to more than one outlet in each bed room, but times are now changing. There is a constant increase in the amount of light that is being used, both for useful and display work, as can be seen by comparing our streets of to-day with those of ten years ago. This indiscriminate use of lighting units of high intensity is having its effect on the eyesight, according to the testimony of oculists, as brought out in Mr. Cravath's paper.

Papers Read Before Technical Societies

THE FLAMING CARBON ARC LAMP

(With Special Reference to the Adaptability to Street Illumination in the United States.)

By L. B. Marks.

PRESENTED AT THE NAT'L. ELEC. LT. ASSN. CONVENTION, ATLANTIC CITY, JULY 5, 1906.

Up to the year 1894 the only arc lamps used in the United States were those of the open arc type. In that year the commercial introduction of the enclosed arc lamp began and during the past ten years the gradual displacement of the open arc lamps by the enclosed arc has taken place. The manufacture of the open arc type of lamp as used in the United States was practically discontinued several years ago, and since that time the arc lamps made in this country have been almost exclusively of the enclosed arc type.

The mean spherical candle-power of the open arc, operated at its best, is almost double that of the enclosed arc taking the same power. In spite of this difference in the total light flux of the lamps the enclosed arc displaced the old open street arc mainly because of the following advantages of the former:

First—Decreased cost of carbons and maintenance.

Second—Greater steadiness.

Third—Better distribution of illumination.

The lighting interests now have offered for their consideration another lamp of the open arc type, popularly known as the flaming carbon arc lamp.

Let us examine briefly some of the characteristic differences between the flaming carbon arc, the ordinary open and the enclosed arc.

In the open arc lamp, as commonly used, the carbons are solid and comparatively free from impurity. The arc is about one-eighth of an inch long, and the light emanates almost entirely from the incandescent points, less than 10 per cent. coming from the arc itself.

In the enclosed arc the carbons must be as pure as possible. The arc, as ordinarily operated, is about three-eighths of an inch long, and as in the case of the open arc, most of the light issues from the incandescent carbon tips.

In the flaming arc lamp, on the other hand, the carbons are cored and mineralized, that is to say, provided with certain mineral substances either in the core or body of the carbon or both, which, when feeding into the arc, greatly increase the light-giving efficiency of the latter. The volatilization of the mineralized carbon produces fumes and a considerable quantity of ash, deposits of which are made largely in the portion of the lamp immediately above the arc. In the flaming arc lamp, unlike the open and the enclosed arcs, the bulk of the light emanates from the arc itself, only a comparatively small portion coming from the carbon points. In the lamp with the carbons co-axially arranged, the length of the arc is about five times that of the ordinary open arc, taking the same current and voltage, or about five-eighths of an inch. When both carbons are arranged to feed from above, the arc tends to creep up the sides of the carbons unless special provision is made for holding it in place, so that in all flaming arc lamps with inclined carbons, a magnetic field is provided in the lamp by which the arc is continuously blown downward, resulting in a long flame measuring one inch to one and one-half inch in length.

Owing to the rapidity with which the carbons are consumed in the flaming arc lamps it has been found necessary to shield the tips as far as possible from "washing" of the air currents in the globe. For this purpose an "economizer" or chamber of highly refractory material is used, which surrounds the ends of the carbons (in lamps in which the carbons are arranged side by side) or encircles the upper carbon (in lamps in which the carbons are arranged one above the other).

The vapor which results from the burning of the mineralized carbons condenses for the most part on the economizer and contiguous portions of the lamp casing. Sometimes a special form of condenser is provided to receive the vapor deposits. As the color of the condensed vapor is whitish the deposits above the arc assist in reflecting the light downward. The arc is extremely sensitive to currents of air in the globe and to variations in the magnetic field and regulating mechanism of the lamp.

The regulating mechanism is housed as completely as possible to prevent access of the fine ash and the destructive fumes from the arc. It is not deemed necessary to give the details of the regulating mechanism of the various lamps of the flaming arc type, as in principle the mechanisms are the same as some of those of the older types of arc lamps, with which we are familiar. It should be stated, however, that in most of the types of these lamps used abroad the mechanism is of the wheel and pinion type

and far more complicated than that to which we are accustomed in lamps now used in the United States. In some of the more recent types of the flaming arc lamp the mechanism has been considerably simplified, but it remains to be seen whether the newer forms will meet the commercial requirements.

In Europe there are no less than ten different makes of flaming arc lamps on the market. Among these may be mentioned the Siemens, Koerting and Mathiesen (Excello), and Beck, which are now on the market in the United States. All three of these are of the inclined carbon design, both carbons feeding downward.

Bremer, who was the first to bring out a lamp of the flaming arc type, in 1898, found that when the carbons were impregnated or built up with substances suitable for augmenting the light-giving efficiency of the arc, such as salts of calcium, magnesium, *et cætera,* the scoria produced by the burning of the carbons, when the latter were placed one above the other, resulted in unsteadiness of the arc and liability to extinction. To overcome this difficulty he arranged the carbons side by side, both feeding downward, so that when the arc was formed between the tips of the carbon the molten scoria resulting from the volatization of the foreign matter in the carbon would drop off without materially interfering with the action of the arc.

cause is minimized. In this type of lamp, the magnetic field, which is required with the inclined carbon lamps, is, of course, unnecessary.

Luminous Efficiency of the Flaming Carbon Arc.—The following measurements are taken from a report of test made by the Electrical Testing Laboratories, New York, October 6, 1905, on a Koerting and Mathiesen flaming arc lamp, and on a standard 5-ampere single-globe enclosed arc lamp. The enclosing globe in each case was slightly opalescent.

The maximum illumination of the flaming arc lamp is at about 45 degrees below the horizontal, in which respect the distribution of its light resembles that of the old open arc. The flaming arc, however, sends its rays with almost equal brilliancy through all the angles from 30 to 75 degrees below the horizontal, while the old open arc quickly drops from its maximum on either side of the 45 degree line of vision, and yields a comparatively small proportion of its total flux between zero and 15 degrees below the horizontal. In the enclosed arc lamp, on the other hand, the horizontal illumination is relatively very large, and at 15 degrees below the horizontal the illumination is not far from the maximum.

In the following table are given enclosed and open arc candle-power measurements taken from the report of the committee for investigating the photometric value of arc lamps, and published in the National Electric Light Association *Proceedings,* 1902. The data are given for the angles immediately below the horizontal,—the important ones in street lighting.

In this table and accompanying chart the wattage stated refers to the power consumption at the arc. The voltage of the alternating-current arc was 70.7, the power factor being 0.85. The enclosed arc lamps were of the single globe type, the alternating current arc being provided with a metallic shade. The globes were of opalescent glass, except for the open arc, which was

TABLE I.

	Flaming Arc Lamp.	Enclosed Arc Lamp.
Positive carbon (diameter)	9 mm. (11/32 in.)	13 mm. (1/2 in.)
Negative carbon (diameter)	8 mm.	13 mm.
Mean amperes	8.0	5.1
Mean volts at arc	45.0	81.0
Mean watts at arc	360	413
Mean spherical candle-power	1020	232
Watts per mean spherical candle-power	0.353	1.78

The Blondel lamp, in which the carbons are arranged one above the other, has met with considerable success abroad. In this lamp a specially constructed mineralized carbon is used, designed to overcome the difficulties resulting from the production of scoria which Bremer found in operating arcs with the carbons co-axially arranged. In the Blondel lamp the lower carbon (which contains practically all of the light-enriching salts) is somewhat larger in diameter than the upper. As the upper carbon in this case produces practically no scoria, the instability of the arc from this

TABLE II.

DISTRIBUTION OF ILLUMINATION OF ENCLOSED ARC, OPEN ARC AND FLAMING CARBON ARC LAMP.

	0° (Horizontal). Candle-Power.	15° (Below Horizontal). Candle-Power.	30° (Below Horizontal). Candle-Power.
Alternating-current enclosed arc, 7.5 ampere (450 watts)	312	375	445
Direct-current enclosed arc, 6.5 ampere (450 watts)	328	465	579
Direct-current, open arc, 9.5 ampere (450 watts)	195	598	1177
Direct-current flaming carbon arc, 8-ampere (360 watts)	917	1312	1754

bare. The candle-power measurements of the flaming arc lamps are taken from the test previously quoted in this paper; the globe of this lamp was of slightly opalescent glass.

From these measurements it will be seen that the flaming arc lamp gives a little over five times the total luminous flux of the enclosed arc lamp using the same amount of power at the arc.

In the test of the flaming arc lamp just quoted, the carbons used contained calcium salts giving a yellowish golden tint to the light. Carbons containing these salts produce the highest luminous efficiency in flaming arcs. It should be noted that when carbons (containing barium salts) producing a white light are employed, the luminous efficiency is materially decreased, the reduction amounting to from 25 to 40 per cent., depending upon the character of the mineralization. When carbons (containing strontium salts) producing a reddish-pink light are employed the luminous efficiency lies about midway between that of the yellow and white light.

Color of Light.—For purposes of street illumination the highly efficient yellow light of the calcium carbon is in general suitable, but for interior illumination where color values are important the yellow light flaming carbon lamp is objectionable. Under the light of this lamp white material appears cream-colored, the shades of yellow are intensified, and the color values at the violet end of the spectrum are naturally distorted. It is quite impossible to distinguish different shades of dark blue from one another, all of them appearing black. With the white light flaming carbons, however, most of the colors have nearly their daylight value.

Steadiness of Light.—In the very nature of things the tendency of a long arc operated in the manner employed in flaming arc lamps is toward unsteadiness. The variability of air currents in the globe, the lack of uniformity in the chemical constituency of the mineralized carbon, the action of the magnetic field (where such is employed),—these and other difficulties conspire to produce unsteadiness in the light.

Distribution of Illumination.—The distribution of illumination of the type of flaming arc lamps now in use is quite different from that of the enclosed arc lamp. Most of the light of the flaming arc lamp is thrown downward in a zone from 30 to 90 degrees below the horizontal, the amount of illumination dropping off quickly toward the horizontal. Mr. W. D'A. Ryan reported recently on a series of tests of flaming carbon arc lamps showing that only about 15 per cent of the total luminous flux lies between the horizontal and 20 degrees below.* ,

* See *Transactions*, Illuminating Engineering Society, March, 1906.

Taking the 6.5-ampere direct-current enclosed arc, it will be noted that from the horizontal down to about 12 degrees below, the enclosed arc gives more illumination than the 9.5 open arc consuming the same power. This means that if the lamps were mounted on poles 25 feet above the ground they would give equal illumination at a distance of about 115 feet from the pole; beyond this distance the advantage would be in favor of the enclosed arc. Now taking the case of the flaming arc lamp consuming 360 watts, or four-fifths of the energy of the enclosed arc, the illumination at a distance of 115 feet from the pole will figure out 2.83 times that of the enclosed arc.

From the distribution of illumination, as shown in the chart, it will be seen that this same proportion holds approximately for all distances from the pole greater than 45 feet, at which point the light strikes the ground at an angle of 30 degrees below the horizontal. At distances less than 45 feet from the pole the proportion rapidly changes in favor of the flaming arc and reaches approximately 10 to 1 at a distance of seven feet from the pole. With the 7.5-ampere alternating-current enclosed arc, the amount of illumination distributed through the most effective zone for street illumination is considerably less than that of the direct-current enclosed arc with the same power consumption. The ratio of 2.83 to 1 cited above, would for the flaming arc and the alternating-current enclosed arc be 3.3 to 1 at 12 degrees below the horizontal, representing a distance of 115 feet from the pole, 3.5 to 1 at 15 degrees below, representing a distance of 95 feet from the pole, and 3.9 to 1 at 30 degrees below, representing a distance of 45 feet from the pole. As in the last case, the proportion increases rapidly in favor of the flaming arc as we approach close to the pole. Hence if we are to obtain the most effective use of the remarkably high luminous efficiency of the flaming arc lamp we must provide the lamp with a reflecting device that will materially modify the distribution of illumination of the arc. There is reason to believe that considerable improvement in this respect may be brought about, but the problem is not a simple one. With the present distribution of illumination, the flaming arc lamp, if mounted on a pole having the same height as the poles now in use for street lighting, would produce an illumination in the immediate neighborhood of the pole entirely out of proportion to that given at a distance of 125 to 250 feet, which is about one-half the distance that now obtains between poles in arc light practice in this country.

To meet this difficulty it is apparent that unless the size of the unit can be materially decreased, the flaming arc lamp must be placed very high above the ground, so high in fact that in most cases serious questions

arise as to the practicability of such a procedure.

Size of Units.—The units now commonly employed are 8, 10 and 12 amperes with 45 to 50 volts at the arc. Owing to the special composition of the carbons and the peculiar nature of the arc, obstacles are encountered which make the practical operation of the lamp difficult when smaller currents are used. Professor Blondel writes to me under date of March 28, 1906, that the smallest practical currents for operating his lamp (before referred to) are "from four to five amperes for direct current and from seven to eight amperes for alternating current." With small currents the luminous efficiency of the arc is very considerably reduced.

cents. It should be noted, however, that the lowest price now quoted in this country for carbons for such service is 15 cents a pair in quantities. In the table which follows, the difference in cost of operation, should the price of carbons fall as low as two cents per trim (an extreme case), is given. The cost of the enclosed arc carbons is taken at 2.75 cents per trim, based on an average life of 77 hours per trim. This cost, it will be noted, is higher than that which obtains in most of the larger stations in the country. The enclosed arcs are assumed to be trimmed once a week, the stub of the upper carbon being used the succeeding week as a lower, which is the usual practice. The flaming arcs are trimmed once a day. The cost of trimming

TABLE III.

STREET ARCS (500 WATTS) OPERATED 4,000 HOURS A YEAR—COST OF CARBONS AND MAINTENANCE.

	Two Enclosed Arcs.	One Flaming Arc. (Carbons 10 Cents per Trim).
Carbons	$2.68	$36.50
Trimming	2.34	8.21
Repairs	1.50	0.75
Inspection	0.90	0.90
Inner globes	0.60	....
Outer globes	0.30	0.15
	$8.50	$46.51

COST OF OPERATION.

CASE I—STREET LIGHTING CIRCUIT.

In order to compare the cost of operation of the flaming arc lamp with that of the enclosed arc lamp now commonly used for street illumination in the United States I have taken the case of a lighting circuit in which the lamps are run all nght every night in the year, on what is commonly known as the 4,000-hour schedule. The present practice in street lighting is to place the poles on which the arc lamps are mounted, about 250 feet or more apart. Assuming that the flaming arc lamp gives five times the illumination of the enclosed arc for the same power consumption (which assumption strongly favors the flaming arc lamp so far as the illumination within the useful zone for street lighting is concerned, as has already been shown in this paper), it is obvious from the law of inverse squares that, for equal illumination midway between the poles, even if the flaming arc were mounted high enough up to give it the advantage of a more favorable distribution of light, it could not replace more than two enclosed arc lamps, each consuming the same amount of power as the flaming arc. Taking a circuit of lamps where two enclosed arc lamps are thus replaced by one flaming arc lamp, the difference in the cost of carbons and maintenance is as follows:

The cost of a pair of flaming carbons suitable for an all-night run is taken at 10 and cleaning the lamps is put at 2.25 cents per lamp, an average figure.

The cost of repairs per lamp is assumed to be the same in both cases, although with the present types of flaming arc lamps the cost of repairs would undoubtedly be very much higher than that of the enclosed arc. As bearing out this conclusion it may be stated that the cost of repairs of the old open-arc lamp now in use in this country is considerably higher than that of the enclosed arc. Mr. S. G. Rhodes, in a paper read at the convention of this association in 1904 (National Electric Light Association *Proceedings,* 1904, page 129), stated that on the circuits of the New York Edison Company operating enclosed arc lamps of the multiple direct-current and series alternating-current types, and series open arc lamps, the cost of repairs of 600 open arc lamps was as large as that of 2,000 enclosed arcs.

The cost of inner globes for the enclosed arc lamps is figured at 15 cents each, two globes per lamp per year being allowed. As an offset against the cost of inner globes for enclosed arc lamps the cost of the "economizer" for the flaming arc lamp should undoubtedly be taken into consideration, but no allowance has been made for this destructible element in the flaming arc lamp. The cost of outer globes is figured at 45 cents each, the average life of a globe being taken as three years. In the flaming arc lamp the life of the globe would probably be considerably less than this.

The station cost of producing energy is taken at values from 0.75 cent to 2.75 cents per kilowatt hour. This cost includes the cost of coal and water and that proportion of the station labor and maintenance account chargeable to the arc lighting system.

It will be noted from the table and chart that when the station cost of producing energy is less than two cents per kilowatt-hour, and the price of flaming arc carbons 10 cents per trim (which is one-third less than the present price in this country), it would not pay in this case to install the flaming arc even if the extra cost of new lamps and of installation of same be left out of consideration, and even though one flaming arc replace two enclosed arcs. When the cost of energy is high, however, the flaming arc lamp makes a more favorable showing than indicated above, particularly if the cost of carbons is reduced. For instance, at station cost of 2.75 cents per kilowatt-hour for energy, the cost of operation of the two 500-watt enclosed arc lamps is $118.50 per year, as against $101.51 per year for one 500-watt flaming arc with carbons at 10 cents a pair, and as against $83.26 with carbons at five cents a pair. On the other hand, if the station cost of energy is very low, say 0.75 cent per kilowatt-hour, the cost of two enclosed arc lamps is $38.50 per year as against $61.51 per year for one flaming arc with carbons at 10 cents a pair, $43.26 a year with carbons at five cents a pair, and $33.31 with carbons at two cents a pair. The cost of operation per year of two enclosed arcs and of one flaming arc for costs of energy and of carbons other than above stated may be readily obtained from the chart.

CASE I—STREET LIGHTING CIRCUIT.

Cost of Energy, Carbons, Trimming, Inspection, Repairs, Globes, 4,000 Hours.

Station Cost of Producing Energy per Kilowatt-Hour.	Two Enclosed Arc Lamps (500 Watts Each).	One Flaming Arc Lamp (500 Watts). Cost of Carbons per Trim.								
	2¾c.	10c.	9c.	8c.	7c.	6c.	5c.	4c.	3c.	2c.
2¾c.	$118.50	$101.51	$97.86	$94.21	$90.56	$86.91	$83.26	$79.61	$75.96	$72.31
2½c.	108.50	96.51	92.86	89.21	85.56	81.91	78.26	74.61	70.96	67.31
2¼c.	98.50	91.51	87.86	84.21	80.56	76.91	73.26	69.61	65.96	62.31
2c.	88.50	86.51	82.86	79.21	75.56	71.91	68.26	64.61	60.96	57.31
1¾c.	78.50	81.51	77.86	74.21	70.56	66.91	63.26	59.61	55.96	52.31
1½c.	68.50	76.51	72.86	69.21	65.56	61.91	58.26	54.61	50.96	47.31
1¼c.	58.50	71.51	67.86	64.21	60.56	56.91	53.26	49.61	45.96	42.31
1c.	48.50	66.51	62.86	59.21	55.56	51.91	48.26	44.61	40.96	37.31
¾c.	38.50	61.51	57.86	54.21	50.56	46.91	43.26	39.61	35.96	32.31

CASE II—STREET LIGHTING CIRCUIT.

It has already been stated that the flaming arc lamp is not at present commercially operative in small units. Let us take a hypothetical case and assume that it is feasible to operate a unit taking one-fifth of the power of the present enclosed arc lamp and giving the same amount of illumination as the latter. If now we replace each enclosed arc lamp of the circuit by such a flaming arc lamp consuming one-fifth of the power, we find the following costs of operation in the two cases, it being assumed that the cost of repairs, globes, cleaning and inspection will check up evenly against each other in both instances.

From the table and chart it is evident that, even waiving the cost of new lamps and expense of their installation, it would not pay in order to secure the same illumination in a street-lighting system in which the station cost of producing energy is one cent per kilowatt-hour (a practical case) to substitute flaming arc lamps taking only 100 watts for enclosed arc lamps taking 500 watts each, unless the price of carbons for the flaming arc falls below three cents a pair. At five cents a pair, which is one-third of the price now quoted in the United States (for the long-burning carbons) and somewhat lower than the lowest price now quoted by the principal makers in Europe, the cost of operation per lamp per year in this supposed case would be $22.60 for the enclosed arc as against $30.46 for the flaming arc. The cost of operation per lamp per year for various costs of energy and of carbons is shown in the table and accompanying chart.

CASE III—COMMERCIAL OUTDOOR CIRCUIT.

In this case the cost of operating a commercial outdoor circuit, with lamps burning on an average approximately three hours a day, or 1,000 hours a year, equipped with the present type of flaming arc lamps, will be compared with the cost of operating a similar circuit equipped with enclosed arcs.

The cost of enclosed arc carbons per trim, cost of one trimming per lamp and the cost of repairs, inspection and globes per lamp per year are taken at the same figures as in the preceding case. The enclosed arcs are trimmed 10 times for this service

Case II—Street Lighting Circuit.

Cost of Energy, Carbons, Trimming, 4,000 Hours.

Station Cost of Producing Energy per Kilowatt-Hour.	Cost of Energy, 4,000 Hours. One Enclosed Arc Lamp (500 Watts).	Cost of Energy, 4,000 Hours. One Flaming Arc Lamp (100 Watts).	One Enclosed Arc Lamp (500 Watts).	One Flaming Arc Lamp (100 Watts). Cost of Carbons per Trim.								
			2¾c.	10c.	9c.	8c.	7c.	6c.	5c.	4c.	3c.	2c.
2¾c.	$55	$11	$57.60	$55.71	$52.06	$48.41	$44.76	$41.11	$37.46	$33.81	$30.16	$26.11
2½c.	50	10	52.60	54.71	51.06	47.41	43.76	40.11	36.46	32.81	29.16	25.11
2¼c.	45	9	47.60	53.71	50.06	46.41	42.76	39.11	35.46	31.81	28.16	24.11
2c.	40	8	42.60	52.71	49.06	45.41	41.76	38.11	34.46	30.81	27.16	23.11
1¾c.	35	7	37.60	51.71	48.06	44.41	40.76	37.11	33.46	29.81	26.16	22.11
1½c.	30	6	32.60	50.71	47.06	43.41	39.76	36.11	32.46	28.81	25.16	21.11
1¼c.	25	5	27.60	49.71	46.06	42.41	38.76	35.11	31.46	27.81	24.16	20.11
1c.	20	4	22.60	48.71	45.06	41.41	37.76	34.11	30.46	26.81	23.16	19.11
¾c.	15	3	17.60	47.71	44.06	40.41	36.76	33.11	29.46	25.81	22.16	18.11

Case III—Commercial Outdoor Circuit.

Cost of Energy, Carbons, Trimming, Inspection, Repairs, Globes, 1,000 Hours.

Station Cost of Producing Energy per Kilowatt-Hour.	One Enclosed Arc Lamp (500 Watts).	One Flaming Arc Lamp (500 Watts). Cost of Carbons per Trim.			
	2¾c.	15c.	10c.	5c.	2¾c.
2¾c.	$16.20	$29.87	$25.72	$21.57	$19.70
2½c.	14.95	28.62	24.47	20.32	18.45
2¼c.	13.70	27.37	23.22	19.07	17.20
2c.	12.45	26.12	21.97	17.82	15.95
1¾c.	11.20	24.87	20.72	16.57	14.70
1½c.	9.95	23.62	19.47	15.32	13.45
1¼c.	8.70	22.37	18.22	14.07	12.20
1c	7.45	21.12	16.97	12.82	10.95
¾c.	6.20	19.87	15.72	11.57	9.70
½c.	4.95	18.62	14.47	10.32	8.45

and the flaming arcs 83 times. The safe allowance under commercial conditions is taken as 100 hours per trim for the enclosed arc and 12 hours per trim for the flaming arc. Above are the data of cost of carbons and maintenance per lamp per year, figuring the cost of flaming arc carbons at 15 cents per trim (present cost):

The total cost of operation, including cost of energy (500 watts), cost of carbons, trimming, repairs, inspection and globes for both types of lamps is given in the accompanying table and chart.

Taking the cost of flaming arc carbons at 15 cents per trim (present cost) and the cost of energy at station-cost of one cent per kilowatt-hour, the cost of carbons and maintenance of the flaming arc lamp per year of 1,000 hours under the assumption above made would be, as shown in the table and chart, $21.13, as against $7.45 for the enclosed arc. Hence, even waiving the additional cost of new lamp and installation, it would not pay from the standpoint of illumination to substitute the flaming arc for existing enclosed arcs under the above conditions unless the flaming arc lamps replace at least three enclosed arcs. Neither would it pay in the above case, with carbons at 10 cents per trim, the relative cost of operating the lamps here being $16.97 and $7.45. But with flaming carbons of five cents a trim, the relative costs of operation being $12.82 and $7.45, the substitution would pay if the flaming arc replaces at least two enclosed arcs. If the cost of flaming arc carbons were reduced to the present cost of enclosed arc carbons (2.75 cents per trim) the relative costs of operation would be $10.95 and $7.45, and in this case still it would not pay to make the substitution unless at least two enclosed arcs are replaced by one flaming arc. From the table and chart the comparative costs of operation for the various costs of energy and of carbons may be read.

In the statements just made, to the effect that it would not pay to make the substitution of the flaming arc for the enclosed arc under the conditions named, it is, of course, understood that the station is selling energy at a uniform price per-

Commercial Outdoor Arcs (500 Watts) Operated 1,000 Hours a Year.
Cost of Carbons and Maintenance.

	Enclosed Arc.	Flaming Arc. (Carbons 15 Cents per Trim.)
Carbons	$0.275	$12.45
Trimming	0.225	1.87
Repairs	0.75	0.75
Inspection	0.90	0.90
Inner globes	0.15	....
Outer globes	0.15	0.15
	$2.45	$16.12

unit for both the enclosed arc and the flaming arc. If, however, the mean spherical candle-power produced per unit of energy is made the basis of comparison, the substitution of the flaming arc for the enclosed arc would pay in every case cited in the table, even at the present cost of flaming arc carbons. For instance, with energy at station cost of one cent per kilowatt-hour, the cost of current, carbon and maintenance of a flaming carbon arc is, as appears from the chart, nearly three times that of an enclosed arc taking the same power; but as the flaming arc for this power gives five times the mean spherical candle-power of the enclosed arc, the cost per candle-power of the former is only three-fifths that of the latter. But unless a very intense illumination in a small space is desired (as, for example, for advertising purposes), no advantage would be gained by substituting an intense light for one of smaller candle-power and less intrinsic brightness.

CONCLUSIONS.

In summation, I conclude:

First—That the flaming carbon arc lamp of commerce produces five times the total luminous flux of the enclosed arc lamp for the same expenditure of electrical power in the arc.

Second—The lamp is well adapted for purposes of illumination where a flood of light is desirable in a single unit, as, for instance, for advertising purposes.

Third—The lamp may be used economically in the lighting of some large interiors, and in large open spaces, such as public squares and wide boulevards, if the lamps are placed at a considerable height, say 40 to 50 feet above the ground.

Fourth—The concentration of such a large flux of light in a single unit renders the lamp unsuitable for purposes of ordinary street illumination in the United States.

Fifth—The advantage of economical production of light is offset by reason of the necessity for frequent trimming with expensive carbons.

Sixth—The fumes and ash given out by the lamp, the unsteadiness of the light, and the objection to frequent trimming, render it unsuitable for most cases of interior illumination.

MERCURY ARC RECTIFIER SYSTEM WITH MAGNETITE LAMPS FOR STREET ILLUMINATION

By W. S. Barstow.

READ BEFORE THE NAT'L. ELEC. LT. ASSN. CONVENTION, ATLANTIC CITY, JUNE 8, 1906.

Many times in the history of the electrical industry the end of a particular commercial development appears to be near at hand, only to be indefinitely postponed by a new discovery in this or some other allied science which accidentally opens up new possibilities. Often, again, the failure in some special line is caused by the absence of a single element which, when forthcoming, turns the failure into an important success. Sometimes all the elements are present, but scattered through different industries, so that there is not sufficient familiarity or knowledge in the hands of any one person or group of persons for a combination to produce the desired result.

Among all the radical changes in the details of the industry during past years the electric arc lamp has shown but little material progress. It is true that there have been evolved the high-tension, the low-tension, the open, the enclosed, the direct and the alternating-current systems, with their many modifications, but in none of these has there been any departure made from the carbon arc and its relatively uniform efficiency for a given illumination. From the day of Sir Humphrey Davey, in 1808, when with a battery of 2000 elements he produced his four-inch flame between charcoal points, to the present refinement of the 150-hour enclosed lamp, progress has been confined more or less to mechanical improvements. The commercial arc lamp of the early day was of open-arc type, requiring 500 watts at the arc to produce what was then termed a "nominal" 2,000-c.p. light or a certain illumination. After passing through the series and multiple stages, the enclosed lamp was evolved, eco-

nomical in maintenance, but with no improvement in consumption of energy. This in the direct and alternating-current form is the type in general use to-day.

There has during the last two years been in course of development a new system (if it may be so called) for outdoor street arc lighting, which not only promises to take an important place in the history of the art, but in many instances to replace the carbon arc. It is actually the first successful effort to increase commercially the efficiency of outdoor arc illumination, while at the same time it opens up new fields where the present type lamps can not be used. The magnetite mercury arc rectifier system requires not only 35 per cent. less energy at the lamp than any existing system for the same illumination, but makes it possible to do outdoor street arc lighting from transmission systems of 35 cycles and under without the use of motor-generator sets or other moving apparatus. In the city of Portland, Ore., about two years ago, this system was installed on a small experimental scale. The street-lighting system at that time had been in successful operation for many years and was of the old-style open-arc type, supplied with direct current.

In the very early days current supplied to Portland was generated by water-power at Oregon City, about seventeen miles south of Portland, and was transmitted to Portland for arc and incandescent lighting. As all arc lighting was done on the high-tension system and incandescent lighting on the high-frequency, single-phase system, each machine had a separate set of feeders from Oregon City to Portland. (This was one of the first instances where, previous to 1892, single-phase, high-frequency machines were operated at a direct pressure of over 4000 volts.) The business increased so rapidly that in 1891 there was transmitted in actual commercial capacity energy for 7200 incandescent and 650 arc lamps by means of the systems above mentioned. As business grew and electric railways were installed in Portland, a second power plant was built at Oregon City, and a 33-cycle, 3-phase, 5000-volt system installed, with direct-connected vertical wheels, especially arranged for a head varying from 15 to 45 feet, and current was transmitted from there by rearranging the original arc and incandescent circuits, each generator being connected to a single three-conductor, three-phase feeder. To each feeder in Portland were connected a set of statics and a rotary transformer, so that there were practically a number of independent generating and transforming plants. To provide for the city lighting motor-generator sets were installed in Portland, each set consisting of a direct-current T.-H. motor directly connected to two direct-current arc machines. Thus, in these early days several transformations were necessary before the alternating current delivered to the substation was finally distributed to the system, and it required 806 watts per lamp of the transmitted energy in the form of 33 cycles, 5000 volts, three-phase, to supply each 500-watt lamp installed in the city. In remodeling the system, as no arc lighting could be taken from the transmission frequency of 33 cycles, it was either a case of using alternating-current, high-tension motor-generator sets, changing the frequency from 33 to 60 cycles, or a high-tension motor directly connected to direct-current arc machines. Under these conditions, and with the original idea of reducing motor-generator capacity and the investment in generating system, several magnetite lamps were installed as an experiment about two years and a half ago, and from that time to the present modifications and improvements were made until now the lamps are equal in all respects to any arc lamp of either alternating or direct-current system. In the meantime lengthy experiments were made with the mercury arc rectifier. About one year ago the results appeared so promising and so much progress had been made in such a short period that an order was placed to install the entire system of over 1200 lamps in Portland with mercury arc rectifiers and magnetite lamps. There have now been in operation in Portland for several months over 800 lamps with rectifiers, and the installation is being rapidly increased as fast as deliveries can be made. The system has proved successful and has fulfilled expectations. Considerable difficulty in the form of static discharges and short life was at first experienced with the tubes. The tubes, which were of small size, were subjected to very rigid requirements on account of the alternating-current pressure of 18,000 volts, a pressure which was very much higher than anything yet attempted with mercury arc rectifiers. The tubes have now averaged over 650 hours and several have exceeded 730 hours, 500 hours being the economical requirement, and anything above this being in the nature of a gain in the original calculated efficiency of the system.

A simple description of the system as installed is as follows: The transmitted energy in the form of 10,000-volt, 3-phase, 33-cycle current enters constant-current transformers, each transformer being of single-phase design, the primary of which is wound for 10,000 volts and the secondary for 16,000 volts. In the secondary is a center connection for the rectifier. The mercury arc rectifier is mounted upon a switchboard panel directly above the oil switch. It is excited by a small amount of 115-volt alternating current energy. This is sufficient to start the rectifier after the same has been moved slightly with a handle for that purpose in order to establish the mercury arc. It requires but a few seconds to start up a circuit, and, when once

started, it is not necessary to maintain the exciting circuit in operation, although this has been the practice up to the present time. In each side of the alternating current of the transformer is placed a reactance and another in the direct-current side. The lamps themselves require four amperes at an average of about 80 volts, or 320 watts, and give an equal illumination to the old-type open lamp requiring 500 watts. As the original distributing system was installed for 10-ampere lamps, losses in these conductors have of course been reduced to a minimum. The present lamps are installed in units of 75 lights. An extra transformer panel with rectifier is provided, so that in the case of any accident happening to the transformer or rectifier the circuit can immediately be plugged in on the spare set. The lamps themselves are, no doubt, familiar to many, having been described in some of the technical papers.

The efficiency of the rotary transformer motor-generator system, as originally installed in Portland to take care of the street arc lighting, from the alternating-current transmitted energy to the direct-current energy distributed to the lamps, was 62 per cent. at or near full load (which is the prevailing condition).

The efficiency of the constant-current transformer mercury arc rectifier system from the alternating-current transmitted energy to the direct-current energy distributed to the lamps is at full load 88 per cent. (at 10 per cent. overload, 89 per cent.); at three-quarter load, 85 per cent.; at half-load, 81 per cent., and at one-quarter load, 80 per cent. This efficiency was obtained by measuring the true watt input of the primary alternating-current energy and the true watt output in direct current, and includes all transformers and reactances, but not the small fan motor used to cool the rectifier tube.

Having thus effected a saving of 26 per cent. in the efficiency of the transforming system itself in Portland, the company secured further economy by the use of magnetite lamps, using 320 watts in the lamp in place of the 500 watts, thus obtaining for 364 watts of transmitted energy the same illumination that originally required 806 watts, or a saving of 1,768 kilowatt-hours per lamp per year; or on the total Portland installation a saving in capacity of 531 kilowatts, and a saving in total energy of 2,121,600 kilowatt-hours per year.

The efficiency of a standard motor-generator set using a high-voltage motor and direct-current arc generator is about 76 per cent., so that if in a modern installation where low-frequency alternating current is transformed by synchronous motor arc machines into direct-current energy for present type of 500 watt arc lamps, there should be installed the constant-current transformer mercury arc rectifier system with magnetite lamps, the gain in efficiency for the same illumination would amount to 294 watts per lamp or 1,176 kilowatt-hours per lamp per year.

The high commercial efficiency of the latter system is due to a very large extent to the simplicity and economy of the rectifier tube itself. A tube of a capacity of about 30 kilowatts has a constant loss of but 25 volts or, at four amperes, 100 watts per hour, while the cost of renewing the tube on the basis of 500 hours' life about equals the cost of labor and renewals on a motor-generator set.

Owing to the fact that both parts of the alternating-current waves are used, the voltage of the alternating current leaving the transformers to the rectifier tube to produce a desired voltage in distributed direct current must be about three times the desired direct-current voltage required by the lamps in circuit. Thus, about 18,000 volts on the secondary of the transformer tubes gives a useful direct-current voltage of about 6,000.

In the use of the magnetite system a commercial question arises which, after very careful consideration, should be definitely answered before the system is adopted to any great extent. I refer to the specifications used in the present public lighting contracts. About fifteen years ago considerable thought was given to the subject by this association, resulting in a campaign of public education which produced the proper result at that time of rating street arc lamps by the "watts in the arc" and dropping out of contracts the terms "normal candle-power." If the price of public lighting is to be fixed by "watts in the arc" on the same basis as present cost, the public will profit by this lamp (due to lamp efficiency) to the extent of 36 per cent., the company gaining in transformer efficiency to an extent of 17 per cent.

The question as to how the public and the companies should share this gain so as to determine under what specifications the illumination should be furnished is a broad one and is a matter that should be carefully considered at this time, so that the introduction of this new system shall be accompanied by a proper standard form of specifications.

NEW ILLUMINANTS

By Prof. H. E. Clifford.

Presented at the National Electric Light Association Convention, June 8, 1906.

The most striking characteristic of the developments in electric lighting during recent years is the great stride which has been taken in the direction of increased efficiency. Nor is this increase confined to any one type of illuminant. Arc, incandescent and vapor lamp alike share in the production of more light with the same expenditure of energy. One cannot but hope that this gain may be followed by a corresponding development in its application to the problems of illumination.

INCANDESCENT LAMPS.

The General Electric Company has developed and placed on the market a new carbon-filament lamp, with a rated efficiency of 2.5 watts per candle and a life equal to that of the 3.1-watt lamp. It is manufactured in 20, 40, 50, 75 and 100-c.p. units, the 20-c.p. lamp taking, therefore, the same energy as the present 16-c.p., 50-watt lamp. Series lamps are also offered, with the new filament.

The distribution curves for a GEM lamp giving 50 mean horizontal candle-power are shown in Figure 1. The shade referred to is of the Prismo Glass Pagoda type.

The tantalum lamp is now obtainable abroad for voltages from 50 to 110, with an efficiency of 2.2 watts per candle. The 110-volt, 2.2-watt, 14.5-c.p. lamp has a life of from 800 to 1,000 hours, often running, however, to 1,500 or 2,000 hours. The 22-c.p., 110-volt lamp has an average efficiency of 1.85 watts with a life of 800 hours. The price of this lamp is still $1.00, or in quantity $0.80, each.

Osmium lamps with a guaranteed efficiency of 1.5 watts and a life of 500 hours are now advertised as for sale in England at a price of $1.50 each, or $1.00 each in quantities for the 25-c.p. units. The allowance for returned lamps is $0.12.

The Kuzel lamp, also making use of a metallic filament, has shown an efficiency of better than one watt, but although it is announced for 110 volts, tests have been published at no higher voltage than 32.

The results already achieved with osmium, tantalum, zirconium (to mention some of the metals which have been proposed as a substitute for the carbon filament in the incandescent lamp) have greatly stimulated research in this direction, from which important results are almost certain to issue. Until, however, these metallic-filament lamps run equally well in all positions, give satisfactory service on both alternating and direct-current circuits, operate at commercial voltages, and can be manufactured at a much lower cost, the carbon-filament lamp with reasonable rates for power and the development indicated by the recent gain in efficiency, will continue to maintain the supremacy it has so long enjoyed.

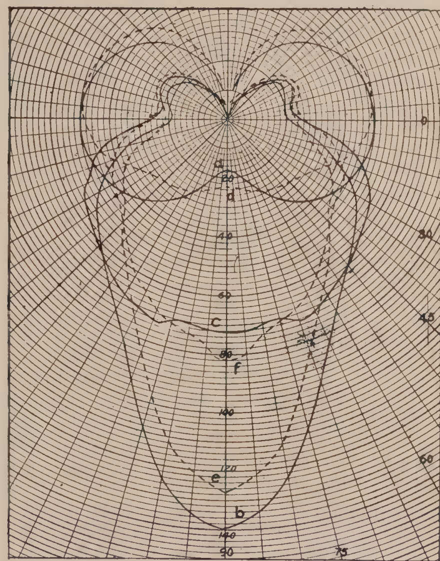


FIG. 1.—THE AVERAGE CANDLE-POWER DISTRIBUTION OF FIVE 125-WATT, TWO LOOPS IN SERIES, GEM LAMPS AT VOLTS WHICH GAVE 50 MEAN HEMISPHERICAL CANDLE-POWER.

	Mean Spherical Candle-Power.
a—Clear, without shade..........	40.66
b—Clear, with concentrating shade	34.53
c—Clear, with diffusing shade....	36.28
d—Frosted, without shade.......	39.52
e—Frosted, with concentrating shade	32.02
f—Frosted, with diffusing shade..	33.81

NERNST SERIES STREET-LIGHTING SYSTEM.

A development of some importance in connection with the Nernst lamp during the past year is the production of a series lamp for street illumination, of moderate candle-power, thus permitting the lamps to be used in cases where a fairly large number of small units is required. The outfit consists of a single-glower lamp connected with a series transformer, the primary coil of which is adapted for a circuit carrying 6.6 or 7.5 amperes constant alternating current. The lamp may, therefore, be used on any of the constant-current series systems and the ordinary 50-light tub transformer will operate about 200 lamps of the new series type. In this particular type

the glower and heater are mounted in a vertical position on a porcelain base, and the heater is made in the form of the helix around the glower. The distribution is shown in the accompany diagram, Figure 2, and is seen to be good for street-lighting purposes.

The watt consumption, including the auxiliary transformer, is about 115. The drop across the primary is 23 volts for a 7.5 ampere circuit, and 26 volts for a 6.6-ampere circut.

LUMINOUS OR FLAME ARCS.

It is only within a comparatively few years, and as a result of the scientific study of the arc, that it has come to be appreciated that the efficiency of such a light source is not dependent on temperature alone. The question of emissive power frequently plays an equal if not greater part in the determination of the ratio of watts to candle-power. It has long been realized that the light from the arc itself between pure carbon electrodes is of extremely low intensity, and more than sixty years ago, experiments were carried on in substituting other electrodes in place of pure carbon. No systematic investigation of the whole question took place, however, until the recent work of Bremer, Auer, Nernst, Blondel, Whitney, Steinmetz, to mention the more noted of the workers in this field.

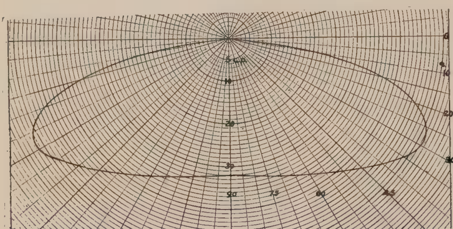


FIG. 2.—NERNST SERIES LAMP. DISTRIBUTION OF LIGHT IN A VERTICAL PLANE.

This work has resulted in marked improvements in two directions: First, the production of a luminous arc between electrodes whose rate of combustion is very much less than with ordinary carbons; and second, the evolution of tne high-efficiency flame arc, in which the ordinary carbon electrodes are replaced by those impregnated with metallic salts. Although these impregnated carbons are to-day manufactured in many forms differing in constructional detail, the purpose with all of them is to obtain a higher light efficiency. Up to the present time this gain in efficiency has been obtained at the expense of the life of the electrodes.

The color of the light with these carbons is determined by the nature of the salts used and may therefore be controlled throughout a wide range. The efficiency, however, is very different for the different salts, the calcium compounds having given the best results. This difference in efficiency is well illustrated by the curves of Figure 3, showing the distribution with flame carbons giving light designated as white, red and yellow, respectively. From the standpoint of efficiency the carbons producing yellow light are distinctly superior.

An examination of the photometric curves, giving the distribution of light with and without globe, shows the importance of a careful study of the optical properties of the glass used, since its selective absorption may bring about a considerable diminution of intensity for the very rays which are emitted by the arc. Such absorption evidently occurs with some of the lamps for which results are given.

In addition to the metallic salts for securing a longer and more brilliant arc, a flux is introduced to assist in the disposition of the slag formed. The presence of this slag makes it desirable in some cases to place the carbons parallel or slightly inclined to each other, rather than in line. In lamps where this arrangement is adopted, a magnetic blower coil maintains a longer arc under ordinary conditions of operation, and acts in addition to prevent the arc from climbing up the sides of the carbons. In a number of flame arc lamps, however, the carbons are placed one directly above the other.

The diameter of the carbons used varies from 8 to 11 mm., the negative being as a rule 1 mm. less in diameter than the positive. The length varies from 325 to 600 mm., whereas the life ranges from 7.25 to 17.5 hours. Lamps are now manufactured having a magazine to contain eight or nine pairs of carbons, thus giving a much increased time of burning.

The production of fumes and the lack of steadiness have combined to render the flame arc lamp undesirable for interior illumination, although it is claimed for one of the most recent types that these objectionable features have been overcome.

For street lighting too large a proportion of the light falls near the vertical, although undoubtedly some reflector might be devised to remedy this defect, at least in part.

VAPOR LIGHTING

It is well recognized, as a scientific principle, that the most efficient means for the transformation of electrical into light energy is electric conduction through rarefied gases or vapors. The practical application of this principle in one or another form has occupied engineers for some years past, and a most promising beginning in actual systems of this character has recently been made.

PHOTOMETRIC TESTS OF VARIOUS LAMPS AND CARBONS.

BLONDEL ARC LAMP. (See Fig. 2.)

Lamp Equipped with Light Opal Outer Globe—Direct-Current, Multiple Circuit.

				Including Resistance.		
Volts at terminals	45	45	50	55	55	55
Amperes	1.5	3	5	1.5	3	5
Watts at terminals	68	135	250	82.5	165	275
Hemispherical candle-power	134	388	868	134	388	868
Watts per hemispherical candle-power	0.57	0.345	0.289	0.615	0.425	0.317
Spherical candle-power	72	212	472	72	212	472
Watts per spherical candle-power	0.945	0.638	0.530	1.14	0.780	0.583

SIEMENS-HALSKE ALTERNATING CURRENT OPEN-ARC LAMP—WITHOUT GLOBE. (See Fig. 3.)

Average Light Distribution in a Vertical Plane.

	Terminals.			Arc.		
	White.	Red.	Yellow.	White.	Red.	Yellow.
Volts	34	34	34	32.5	32.5	32.5
Amperes	20	20	20	19.85	19.85	19.85
Watts	578	578	578	527	527	527
Hemispherical candle-power	963	1122	1614	963	1122	1614
Watts per hemispherical candle-power	0.601	0.515	0.358	0.547	0.470	0.327
Spherical candle-power	482	561	807	482	561	807
Watts per spherical candle-power	.1.202	1.030	0.716	1.094	0.940	0.653

EXCELLO CARBON LAMP. (See Fig. 4.)

10-Ampere, Direct-Current

READINGS TAKEN IN PLANE PERPENDICULAR TO PLANE OF CARBONS.

			Including Resistance	
	With Globe	Without Globe	With Globe	Without Globe
Volts at terminals	49.3	46.3	55	55
Amperes	10	10	10	10
Watts at terminals	493	463	550	550
Mean hemispherical candle-power	1457	3029	1457	3029
Watts per hemispherical candle-power	0.339	0.153	0.378	0.181
Mean spherical candle-power	862	1695	862	1695
Watts per spherical candle-power	0.572	0.273	0.638	0.324

LUMINOUS ARC LAMP, 220-VOLT, DIRECT-CURRENT MULTIPLE, 3 AMPERES, 105-VOLT ARC, COMPARED WITH DIRECT-CURRENT SERIES LAMP, 4 AMPERES, 75-VOLT ARC. (See Fig. 5.)

Series lamp equipped with porcelain reflector.
Multiple lamp equipped with nickel reflector.

	Direct-Current Series		Direct-Current Multiple	
	Terminal	Arc	Terminal	Arc
Volts	76	74.8	220	105
Amperes	4	4	3	3
Watts	304	296	660	315
Mean hemispherical candle-power	403	403	242	242
Watts per mean hemispherical candle-power	0.755	0.735	2.73	1.30
Mean spherical candle-power	225	225	150	150
Watts per mean spherical candle-power	1.35	1.31	4.40	2.10

MAGNETITE LAMPS COMPARED WITH BREMER AND BLONDEL LAMPS.

(SEE FIG. 6.)

Blondel lamp equipped with light opal globe. Bremer lamp run without globe and with light opal globe. Magnetite lamp equipped with stationary electrode of copper, flat nickel-plated reflector and clear closed-base globe. Standard five-eights-inch magnetite electrode.

GLOBES.	BREMER.		MAGNETITE.		BLONDEL.
	None.	Opal.	Clear.	Clear.	Opal.
Volts at arc	41	41	80	80	46
Amperes	9.1	9.1	4	7	5
Watts at arc	372	372	320	560	226
Mean hemispherical candle-power	1811	968	368	992	868
Arc watts per mean hemispherical candle-power	0.205	0.384	0.870	0.565	0.260
Mean spherical candle-power	914	581	216	580	472
Arc watts per mean spherical candle-power	0.407	0.641	1.48	0.966	0.479

SIEMENS FLAMING ARC LAMP, 12 AMPERES, DIRECT-CURRENT, MULTIPLE CIRCUIT. (SEE FIG. 7.)

Carbons marked "Siemenskohle Effekt."
Positive 10 mm., negative 9 mm.—yellow.
Lamp equipped with light opal globe.

	Terminal.	Arc.
Volts	55	43
Amperes	12	11.85
Watts	660	510
Mean hemispherical candle-power	1283	1283
Watts per mean hemispherical candle-power	0.515	0.390
Mean spherical candle-power	752	752
Watts per mean spherical candle-power	0.878	0.678

FLAME ARC CARBONS. (SEE FIG. 8.)

USED IN BAUSCH ARC LAMP—DIRECT-CURRENT, MULTIPLE-CIRCUIT TERMINALS.

	ELECTRA.		BREMER.		CONRADTY.	
	Opal Globe.	Without Globe.	Opal Globe.	Without Globe.	Opal Globe.	Without Globe.
Volts	47	47	43	43	43	43
Amperes	8.2	8.2	9	9	9	9
Watts	385	385	385	385	385	385
Hemispherical candle-power	370	585	798	1438	965	1870
Watts per hemispherical candle-power	1.04	0.649	0.481	0.268	0.390	0.205
Spherical candle-power	200	293	475	719	559	935
Watts per spherical candle-power	1.93	1.30	0.81	0.536	0.688	0.410

RATIO OF MEAN SPHERICAL CANDLE-POWER.

	Opal Globe.	No Globe.
Electra	1	1
Bremer	2.38	2.44
Conradty	2.80	3.19

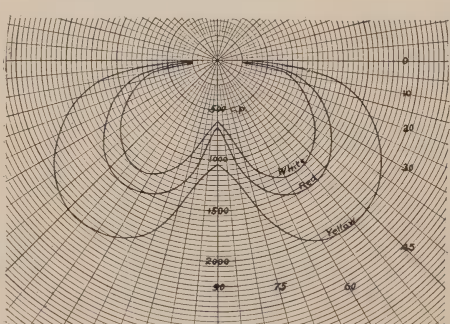


FIG. 3.

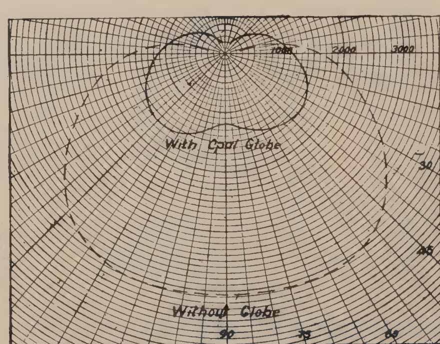


FIG. 4.

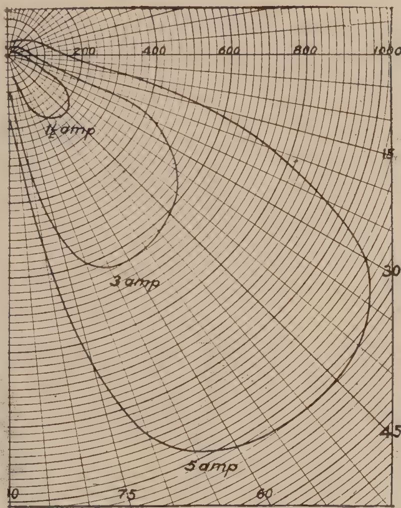


FIG. 2.

Under ordinary conditions an enclosed vapor, even though rarefied, offers an extremely high resistance to the passage of

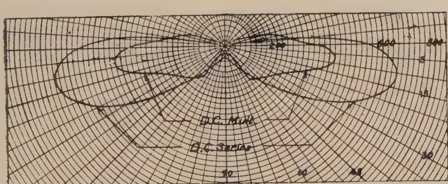


FIG. 5.

the electric current, but if the vapor be ionized it becomes a good conductor. The starting of the current through a vapor is

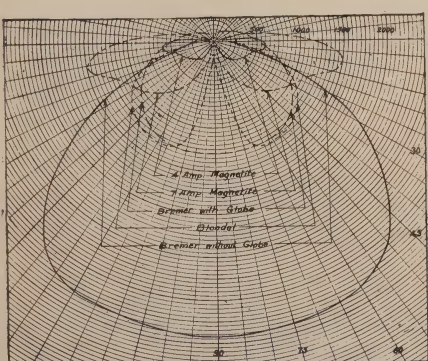


FIG. 6.

thus a problem which does not exist with ordinary metallic conduction, and in this starting, and indeed thereafter, the cathode or negative electrode plays the significant part.

The current may be started either by bringing the two electrodes together and then separating them, under moderate voltage, or by submitting the vapor to a high-voltage shock. In the latter case the conduction once started requires only a low

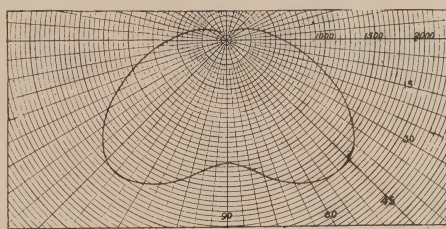


FIG. 7.

voltage for its continuance, provided the direction of flow be not reversed. If, however, the electrodes reverse their sign, as is the case with alternating currents, the high-voltage shock must evidently be repeated with a rapidity determined by the frequency of the alternations.

The spectrum of the light emitted by luminous gases and vapors is not continu-

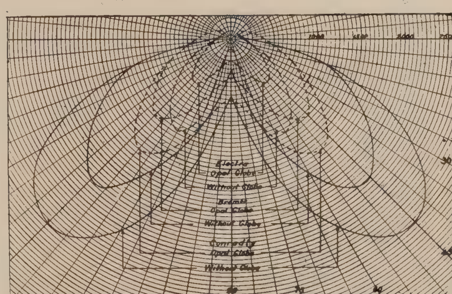


FIG. 8.

ous, except for high density and temperature, but consists of bright lines whose number and color are characteristic of the gas or vapor. This makes it possible to control the color of the light to a degree, but also has its limitations in that a single vapor, admirable in other respects, may lack the desired color. In order to supply this deficiency a mixture of several vapors may, of course, be used for the conducting medium, but no one of the components must be of such a character as to attack

the envelope which contains the mixture.

The envelope must not only be strong, durable and cheap, but it must be highly transparent and must not show selective absorption, at least for the particular wave lengths emitted by the vapor which it contains. It must be easily manipulated and worked. Glass tubing best fulfils these requirements, and although quartz has been suggested as a substitute, the efficiency obtained by its use has not equaled that for glass.

Vapor lighting commends itself on account of the low intrinsic brilliancy and consequent avoidance of retinal fatigue, and also from the standpoint of distribution, the diffusion obtainable being far more perfect than is possible with light sources of a point character. It is, of course, possible to have so perfect a diffusion that all contrast is eliminated, a result absolutely undesirable since it causes fatigue in the effort to judge the relative distances of objects within the field of view. The elimination of sharp, deep shadows, on the other hand, is certainly eminently desirable.

The Cooper Hewitt mercury vapor lamp and the Moore vacuum tube light represent the present day commercial systems of vapor lighting.

COOPER HEWITT MERCURY VAPOR LAMP

This type of lamp makes use of the vapor of mercury in an otherwise exhausted tube, and is now manufactured for both direct and alternating current. Although the device of starting the lamp with a high-voltage shock has been used, the current is generally started by tilting the lamp, thus bringing the electrodes in contact through a stream of liquid mercury. The tilting may be done by hand or accomplished automatically. The light is limited in color by the fact that the spectrum of the vapor of mercury contains no red rays, and the lamp is useless, therefore, where accurate color comparison is essential. In its physiological effect it seems to be satisfactory.

Reference has already been made to the fact that the cathode or negative electrode is the significant factor in enclosed vapor lamps. A difficulty of some consequence in such lamps is the physical disintegration of this electrode brought about by the current; indeed, for currents of considerable magnitude it seems necessary that the cathode should be regenerative, that is, should be able to reconstruct itself on being disintegrated by the current. Mercury fulfils this condition most admirably.

The stability of operation has been shown to depend largely upon the wandering of the bright spot found at the negative electrode. Every lamp for a given impressed voltage has a minimum current below which the arc goes out. The magnitude of this current may be reduced by devices intended to prevent the wandering of the bright spot on the cathode, and also by the presence of inductance in the lamp circuit.

It is evident from the curves given in Figure 9 that the consumption of the lamp varies considerably as the current alters, showing a well-marked minimum. This occurs for a current of about 3.5 amperes and gives the value at which the Cooper Hewitt lamps are ordinarily run. In the figure Curves 1 and 2 show the relation of watt consumption to current for the lamp, including and excluding the auxiliary apparatus. Curve 3 gives the relation of

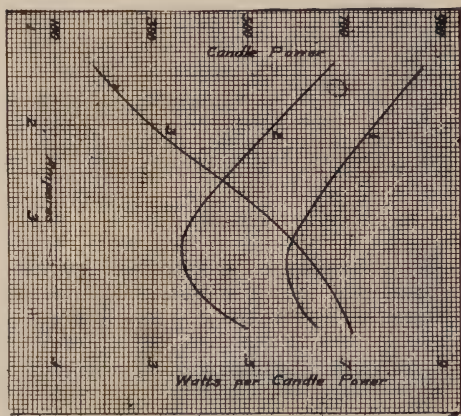


FIG. 9.

candle-power and current. The lamp for which these results hold was a type H, direct-current form.

The direct-current, type K, lamp is intended to be run on a supply voltage of from 98 to 122 volts when installed singly, or from 196 to 244 volts when two lamps are installed in series. In this lamp the length of the light-giving tube is 45 inches, the candle-power rating 700, thus giving an efficiency of 0.55 watt per candle. The type H lamp is intended to be run on circuits of from 98 to 122 volts, two in series, or from 196 to 244 volts when four lamps in series are used. This lamp has a candle-power rating of 300, and when run two in series gives an efficiency of 0.64 watt per candle.

The alternating-current, type C, lamp makes use of the principle of the mercury rectifier in addition to the mercury vapor lamps, the current through the lighting tube being unidirectional. The lamp is started in precisely the same manner as the direct-current lamp, and consists, like the direct-current lamp, of tube, holder, reflector and auxiliary. Its efficiency is a maximum at about 3.5 amperes, at which it is rated. The lamp is intended to run on any frequency between 50 and 150, and on any

TYPE K LAMP

104-Volt Circuit

	With Reflector	Without Reflector
Current	3.5 amps.	3.5 amps.
Average watts	364	364
Mean hemispherical candle-pawer	1200	575
Watts per candle hemispherical	0.303	0.63
Maintenance for 1000 hours in cents	279	279
Maintenance per k.w.-hr. in cents	0.767	0.767
Miantenance per k.w.-hr. per candle-power in cents	0.00064	0.00133
Maintenance per k.w.-hr per candle power-1000 hours in cents	0.64	1.33
Total cost of current per year at 5 cents per k.w.-hr, (4300 hours)	$78.26	$78.26
Cost of maintenance per year per lamp for 4300 hours	$12.00	$12.00
Combined current and maintenance cost per year per lamp	$90.26	$90.26
Combined current and maintenance cost per candle-power per year	7.5c.	15.7c.
Combined current, maintenance and initial cost per lamp first year	$125.26	$125.26
Combined current, maintenance and initial cost per candle-power first year	10.45c.	21.8c.

commercial voltage. The power factor is about 80 to 85 per cent. The light-giving part of the tube is 28 inches long, giving 425 candle-power at an efficiency of about 0.65 watt per candle for 275 real watts and 325 apparent watts in the tube. The candle-power drops off gradually and reaches about 75 per cent of its initial value in 1,000 hours.

If variations in line voltage occur, most of the variation will be taken up by the ballast, some by the series resistance, and the remainder by the lamp. This holds for lamps on both direct and alternating-current circuits. Thus for an increase of 10 volts on a 110-volt circuit, the current increases from 3.50 to 3.66 amperes. For a decrease of 10 volts, the current varies from 3.50 to 3.15 amperes.

It is important that the leads between the lamp and the auxiliary be short and straight, otherwise the lamp may go out, due to the inductive action in these leads. The ballast is set at 3.5 amperes before leaving the factory, and works best at this particular setting.

Tubes are guaranteed to run one year at 12 hours per day, or approximately 4,300 hours per year. The price of $12 for a new tube in this time makes the maintenance charges comparatively low.

The above table gives figures of the cost of the lamp and its maintenance, together with the current and watts consumed and the candle-power:

Attempts have been made to improve the color of the light of the mercury vapor lamp by the addition of the vapors of lithium, potassium and rubidium. These vapors, however, will attack the tube if made of quartz. Recently a patent has been granted to Mr. Hewitt for the introduction of inert gases, such as neon, nitrogen or argon, which are to be introduced to improve the quality of the light.

Various means, external to the lamp itself, have been suggested for improving the color of the light from the mercury vapor tube. Thus the use of fluorescent screens to supply the deficiency in the red rays has been proposed and rhodamine has been tried, but with no very marked success. Undoubtedly, the best way of supplying what the mercury vapor lamp lacks in color is to use incandescent lamps, and these have been adopted in conjunction with this type of lamp in some cases with fairly successful results.

In the Moore system of vacuum tube lighting the ionization of the vapor is intermittent, rather than continuous, since alternating current is used. Thus the Moore lamp is a true alternating-current lamp, the electrodes reversing their sign at every alternation. It is necessary, therefore, that high voltage should be applied to the terminals of the lamp in order that the vapor may be broken down at each reversal of the current by a high-voltage shock. The frequency of these discharges through the tube must be such that the interval between successive discharges is not observed by the eye. A patent has been recently granted to Mr. Moore for automatically maintaining the vacuum at its proper value, thus preventing the rise in resistance which is so apt to take place in vacuum tubes.

In the present "Moore Electric Daylight System" of illumination all of the distinctly electrical apparatus is placed in a single steel casing or box. A low-potential alternating-current circuit supplies the apparatus with 60-cycle current. From the box extends the tube used for illuminating

purposes, which is, therefore, in the form of a loop and contains a non-metallic gas

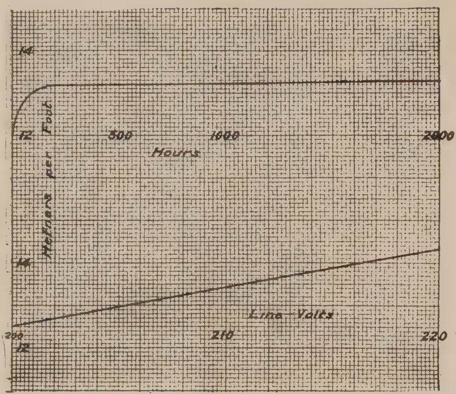


FIG. 10.

or vapor under very small pressure. The length of this tube can vary from a few

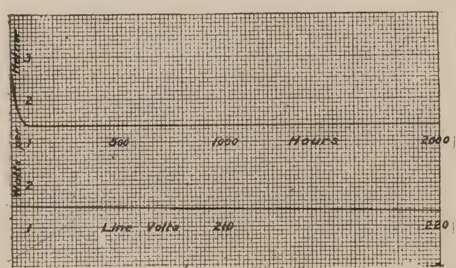


FIG. 11.

feet to several hundred feet. The diameter of the tube can be changed as well as its

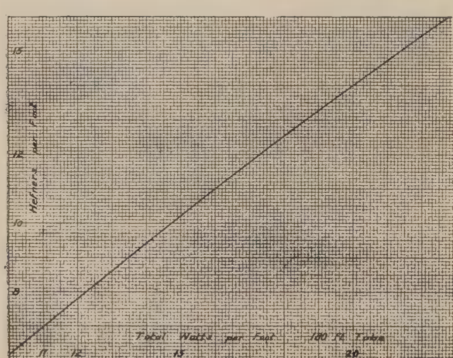


FIG. 12.

shape, length, and the color of the light which it gives.

The terminals of the tube which are within the box contain carbon internal electrodes. This box also contains a step-up transformer, the high-potential terminals of which are attached directly to the tube electrodes and therefore never emerge from the sealed box, and the only wires extending into the box are the ordinary low-potential

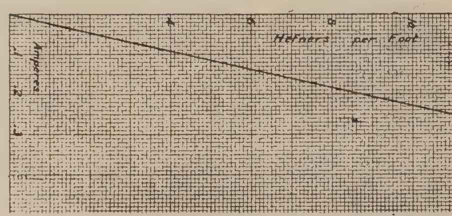


FIG. 13.

service wires. These boxes are fireproof, and since the glass tube extending throughout the area to be lighted is harmless to either life or property, the system may be called a safe one. The long tube takes the place of the conduits, wire, sockets, lamps,

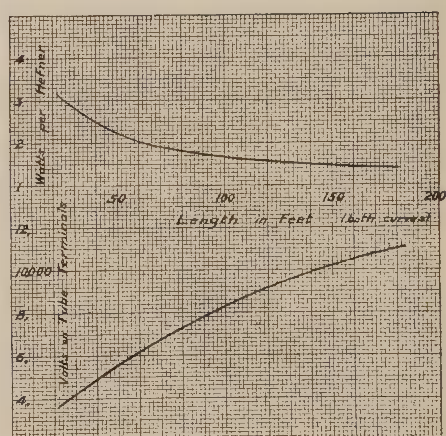


FIG. 14.

et cætera, of the ordinary lighting system. The color of the light may be controlled by the character of the gas or vapor with which the tube is filled.

These long tubes are constructed on the premises by hermetically sealing together lengths of glass tubing, each eight feet six inches long, by means of a new gas fire especially invented for the purpose. Mr. Moore has also worked out the other ingenious and necessary tools for doing this

work rapidly, cheaply and in a manner that is thoroughly practical.

The relation among the different factors concerned in the Moore system is well shown by the curves.

Curve 5 shows the relation of Hefners per foot to the time in hours. It indicates that the brilliancy of the tube automatically increases during the first 100 hours of its life, and then remains practically constant up to 2,000 hours, which was the limit of the experiment on this particular tube.

Curve 6 shows the relation of the line voltage to the brilliancy and indicates that the relationship is practically linear in character. Hence variation in voltage on this system produces much less change in candle-power than with the incandescent lamp.

Curve 7 shows the relation of watts per Hefner to hours and is related with the increase in brilliancy with time shown in Curve 5. After the first 100 hours the efficiency is constant.

Curve 8 shows the relation of efficiency in watts per Hefner to line voltage, indicating an increased efficiency as the line voltage increases. This increased efficiency, however, is very slight, showing that the tube has a practically constant efficiency over wide ranges of voltage. It is also to be remarked that the life of the tube is not dependent upon the voltage.

Curve 9 shows the relation of the brilliancy to the watts per foot of tube for a 180-ft. tube, and indicates sensibly linear relationship.

Curve 10 shows the relation of the brilliancy expressed in Hefners per foot to the current through the tube and as would be expected from what has already been shown for voltage and wattage, this relationship is also linear.

Curve 11 shows the increased efficiency which is obtained by increasing the length of the tube. For a 180-foot tube the efficiency is slightly less than 1.4 watts per Hefner.

Curve 12 shows the relation of voltage to length of tube, indicating that for the greater lengths of tube the voltage required does not increase as rapidly as the length of the tube itself.

Some typical installations of the Moore tube, and also a view of a terminal box, are shown in the accompanying reproductions from photographs. The first tube to be installed was in a photographic gallery in New York City in November, 1903, and this tube has been in continuous operation since that time. Great care is necessary in the selection of electrodes in order that they may not disintegrate. In the tubes examined by the writer this darkening of the tube at the electrodes was evident in but one case. As yet, with the commercial limitations in the generation of high-voltage direct-current, no direct-current tube has been developed for commercial use. There is, however, no inherent difficulty in the operation of such a tube. The most serious limitation of the Moore tube is the fact that it can not be economically used for small units, since each tube requires its special terminal box. In certain cases, also, the liability to fracture of the tube will render its use inadvisable. Its field is the illumination of large areas and in this its seems to have a promising future.

CONCLUSION

The concentration of effort in the securing of higher efficiency tends to make one lose sight of the danger of further increasing the intrinsic brilliancy, a danger all too plainly indicated in some of our modern illuminants. The last word in increased efficiency has not yet been spoken, but even so, the time seems ripe for greater devotion to questions of distribution.

HIGHER-EFFICIENCY INCANDESCENT LAMPS—THEIR VALUE AND EFFECT ON CENTRAL STATION SERVICE

By Francis W. Wilcox.

(Presented at the Nat'l. Elec. L't. Assn. Convention, June 8.)

We are face to face with epoch-making developments in the electric incandescent lamp, by which without reduction in life materially higher efficiencies are obtained, and still higher efficiencies are in prospect.

The discovery by Dr. Whitney at the General Electric Company's research laboratory of the so-called "metallizing" or graphitizing of carbon filaments has already given a veritable 2.5-w.p.c. filament, with promise of still higher efficiencies to come. The discovery and development of the tantalum filament gives a practical lamp of an efficiency of two watts per candle, which is now in regular commercial production in Germany and will soon be manufactured in this country. Experiments carried on in this country and Europe indicate the possibility of manufacturing a 1.5-w.p.c. or even a 1-w.p.c. lamp so that there is a substantial basis for the belief that within a few years such lamps will be on the market. For the purpose of this paper, however, the question of who invents the lamps, or when they will become marketable, is immaterial. The point is that they are a commercial possibility to be reckoned with in the future.

These remarkable developments possess naturally a special and vital interest to every electric lighting company, and it behooves each central-station manager to study the effects that will follow from the introduction of higher-efficiency lamps and to consider what policy it is wisest and best to adopt for them.

Any one would naturally expect electrical

men to rejoice over an advancement in the art by which the electric incandescent lamp may be enabled to hold its own against the Welsbach and other improved competitive illuminants, but there are some central-station managers who regard the higher-efficiency lamp as not an altogether unmixed blessing. Even when regarded favorably, opinions as to the value of higher-efficiency lamps and the effects that will be produced by them differ very greatly among central-station managers.

The time is ripe, therefore, for a full discussion of this very important question. The endeavor will be made in this paper to present a clear analysis of the situation, so that the deducible results can be correctly traced. This analysis, in connection with costs and data on the new improved lamps, will provide a good basis for the study and discussion of the conjectural effects on the electric lighting business. The new General Electric metallized or "GEM"-filament lamp, as it is termed, will be taken as the subject for this discussion.

THE NEW GEM-FILAMENT HIGH-EFFICIENCY LAMP.

The GEM filament gives a lamp with a mean initial horizontal efficiency of 2.5 watts per candle and a useful life practically the same as the present 3.1-w.p.c. lamp, so that we have the following comparison of the new with the present lamp:

	Ordinary Lamp.	GEM Lamp.
Initial efficiency in watts per candle-power	3.1	2.5
Total watts for 16-c.p.	50	40
Total watts for 20-c.p.	62	50
Useful life of both the new and present lamp	450 to 500 hours	
Per cent. of saving of power, new lamp over present lamp	20 per cent.	

The relative life values of the new and present lamp at various efficiencies are clearly shown by Table II and the curves in Figure 1. From these tables and diagram we see that in comparison with the present carbon-filament incandescent lamp

The new GEM-filament lamp saves 20 per cent in energy consumed for same life and candle-power service.

The new GEM-filament lamp gives 25 per cent more candle-power for the same energy consumed and equal life and candle-power maintenance.

The probable cost of the new lamps will be more than the cost of the present lamps, and for the purpose of this paper we will take the cost of the 16 to 20-c.p. GEM-filament lamp as 20 cents as compared to 16 cents for the present lamp in order to have a definite basis for calculation.

From this information on the lamp we can determine the saving the new lamp will secure to users and therefore its value or worth.

VALUE OF THE HIGH-EFFICIENCY LAMP TO THE CONSUMER.

The saving to the consumer paying for current on a regular meter basis is readily calculated.

The consumer's saving using 16-c.p. new lamps in place of the 10-c.p. present type is given for different rates and different efficiencies, Figure 3, covering 1000 hours' service.

Assuming that central station is supplying free renewals of the present 3.1-w.p.c. lamps, we see from Table III and Diagram 3 that the consumer could buy his own renewals of the new 2.5-w.p.c. lamps at 25 cents each and save money at all rates above 5 cents per kilowatt-hour.

VALUE TO ISOLATED PLANTS.

In the case of the isolated plants of the country the substitution of the new 16-c.p. lamp of the same useful life as the present 16-c.p., 3-5-w.p.c. lamp, would result in an annual saving of over $1,000,000, covering power and apparatus costs. The additional annual cost for lamp renewals of the new lamp would not, however, exceed one-fourth of this saving.

VALUE TO CENTRAL-STATION COMPANIES.

The value of a higher-efficiency lamp to central-station operating companies is a complicated question.

With companies selling current by meter at various rates per kilowatt-hour and limited to the same number and candle-power of lamps supplied, and the same hours of use, there would theoretically appear to be somewhat of a reduction in income, and a somewhat increased cost of lamp renewals, but as I will show later I do not expect to see the income reduced, but on the contrary largely increased.

Where companies are selling by the lamp-hour, or flat charges per lamp per month, the new higher-efficiency lamps have a distinctly positive value.

This value lies in the saving a higher-efficiency lamp will secure (for a given lighting output) in the station capacity and in generating costs that are strictly proportionate to output.

This saving is made up of two items:

(a) The saving in generating costs that are strictly proportionate to output.

(b) The saving in fixed charges on the investment in generating apparatus.

As regards the generating costs that are strictly proportional to the output, the principal item is boiler fuel. Engine and boiler-room labor and repairs are effected slightly. Assuming that boiler-room labor alone is affected, it would be about the equivalent of the slight changes in various other expenses. So that we can take fuel and boiler-room labor costs to represent the total of those generating costs that are strictly pro-

portional to output, and calculate therefrom the value of the current consumed by the new high-efficiency as compared to the present lamp. These costs should be taken at their value at the lamp, *i. e.*, the costs obtained by dividing the fuel and boiler-room labor costs for incandescent lighting by the output delivered and metered at the lamp.

For this purpose, let us assume several values for fuel and boiler-room labor costs per kilowatt-hour of current delivered at lamp, *viz.*, 1 cent, 0.5 cent and 0 cent per kilowatt-hour, covering the cases of steam-operated plants down to water-power plants, for which these charges are taken as nothing.

With respect to the saving in fixed charges, the items are taxes, interest and depreciation on boilers, engines and dynamos. Should a station introduce higher-efficiency lamps, say a 40-watt lamp for a 50-watt lamp, it would have available for same number of lamps supplied 20 per cent more capacity of generating equipment. This added capacity of apparatus, considered as an asset, might be converted into cash to reduce investment account; or, more logically, it would serve to provide needed capacity for increased business. As time goes on and the demand for light increases, this excess station capacity is realized on without adding to investment, and therefore central stations can consider this a saving.

We can take taxes, interest and depreciation charges at a total of 12 per cent. The investment per kilowatt for the increment or decrement of generating apparatus will vary for different stations, but we can assume $125 as a safe value. On this basis we obtain with our total fixed-charge percentage of 12 per cent $15 per year as the fixed charge per kilowatt of station capacity.

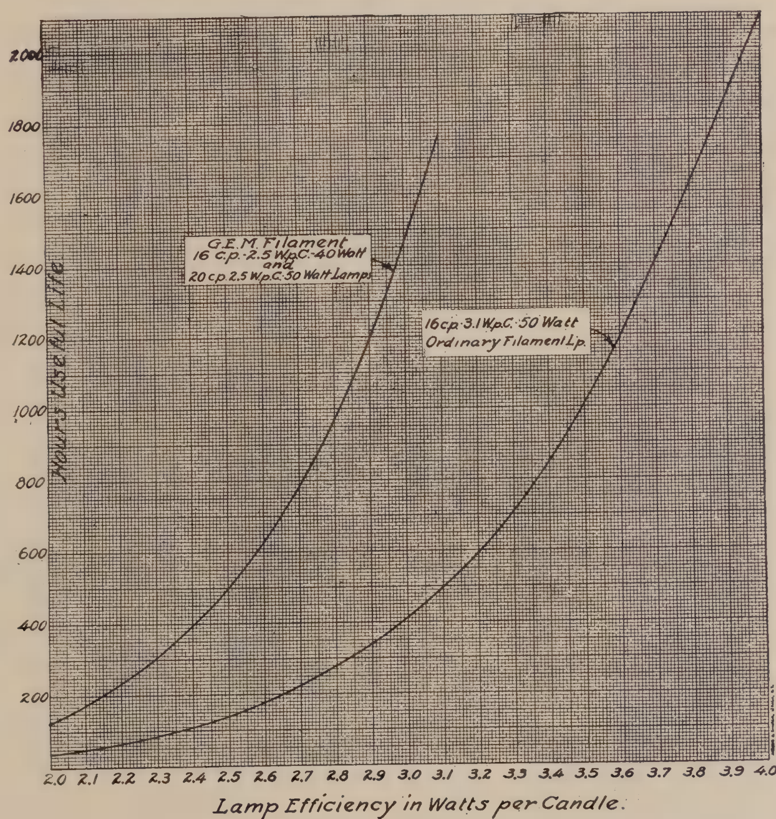


FIG. 1.—USEFUL LIFE OF CURVES OF NEW GEM-FILAMENT LAMP AND PRESENT CARBON-FILAMENT LAMP.

This annual fixed-charge cost of $15 per kilowatt can be reduced to the value per lamp per year as shown in the following table:

Fuel and station labor costs, 1c. per k.w.h. lamp costs—
New GEM filament...............20 cents
Tantalum " ....60 cents
Present " ....16 cents

	C.P.	W.P.C.	Watts.
1. Present filament ..	16	3.1	50
2. " " ..	16	3.5	56
3. New Gem " ..	16	2.8	45
4. " " " ..	16	2.5	40
5. " " " ..	20	2.5	50
6. Tantalum " ..	25	2.0	50

hours' use per year. This basis is the theoretically correct one, as it covers the change in candle-power of lamp.

If we take the cost of the present 16-c.p., 50-watt carbon-filament lamp as a basis at 100 per cent, and plot the values for the other lamps under comparison in percentages of the present 16-c.p., 50-watt lamp for different hours' use per lamp per year, we have the curves as shown in Figure 5.

Figure 5 gives the percentage relation for equal candle-hour values, and presents an

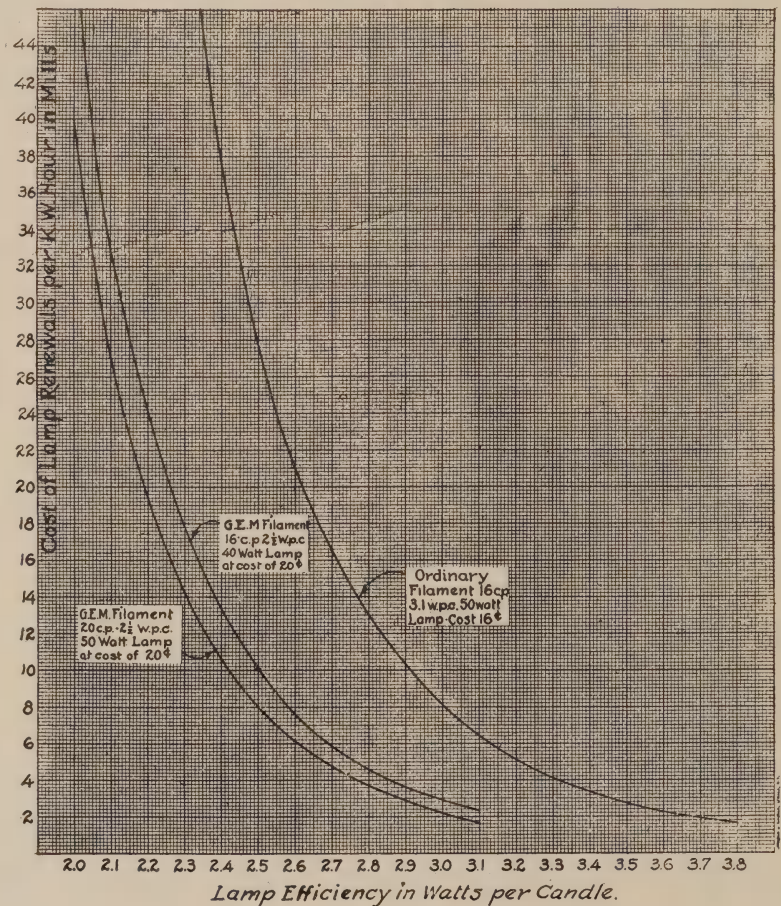


FIG. 2.—LAMP-RENEWAL COST CURVES OF GEM LAMPS.

THE COST OF PRODUCING A CANDLE-HOUR OF LIGHT WITH LAMPS OF DIFFERENT EFFICIENCIES.

To determine the cost on the candle-*hour* or kilowatt-*hour* basis it is necessary to determine how long the lamps are used. For this purpose we can assume several values for the annual hours' use of lamp per year and determine the candle-hour cost therefrom by dividing the fixed charge per 1000 candles (in above table) by the assumed interesting diagrammatic picture of the value of higher-efficiency lamps as compared to the present 3.1-w.p.c. lamp.

In studying this diagram it should be noted that the average hours' use per lamp by consumers does not in general exceed 1000 hours per year or three hours per day.

From the curves in Figure 5 we see:

First—That up to the 1000-hour point the costs of producing a candle-hour of light with the new GEM-filament, 16-c.p., 2-5-

w.p.c., 40-watt lamp (curve No. 4) is less than that with the present 16-c.p., 3-1-w.p.c. lamp (curve No. 1).

Second—That within the limit of values taken (2000 lamp-hours' use per year) the new GEM 20-c.p., 2.5-w.p.c., 50 watt lamp (curve No. 5) is less than the cost given by the present 16-c.p., 3.1-w.p.c. lamp (curve No. 1).

Third—That this is also true of the new GEM 16-c.p., 2.8-w.p.c., 45-watt lamp (curve No. 3), which is also 20 per cent below the cost given by the present 16-c.p., 3.5-w.p.c. 56-watt lamp (curve No. 2), these two lamps having equal life (1000 hours).

Fourth—That the new tantalum lamp (curve No. 6) is less than the cost given by the present 16-c. p., 3.1-w.p.c. lamp (curve No. 1), except beyond 1850 hours' use per lamp per year (or five to six hours' use per day).

EFFECT UPON THE QUESTION OF SELLING LIGHT BY THE KILOWATT HOUR.

This is an interesting comparison of values of lamps of different efficiencies, but it must not be overlooked that the basis of comparison assumed is equal light or number of lamps. The comparison is a true one for a factory or building or a street railway requiring a certain lighting result without reference to any sale to consumer.

Where central stations are selling by the lamp or candle-hour, this comparison also holds for actual results. Unfortunately, however, the majority of central-station selling is done by the kilowatt-hour, so that our actual comparisons of the new and present lamps must be made on the basis of kilowatt-hours absolute instead of by kilowatt-hours per lamp or by candle-hours.

On the absolute kilowatt-hour basis with load factor unchanged, the change to higher-efficiency lamps would theoretically appear to increase the central-station kilowatt-hour costs by the slight amount of increase in cost of lamp renewals for the new lamp.

For the same light and hours of use the total kilowatt-hour output with higher-efficiency lamps would be reduced and the total cost probably in a similar proportion so that the cost per kilowatt-hour would not theoretically be reduced but might remain either unchanged or slightly increased.

So far as the central station is concerned with a given output in kilowatt-hours to sell, and paid for it only by the kilowatt-hour, it would appear to make practically no difference in the economy of the station

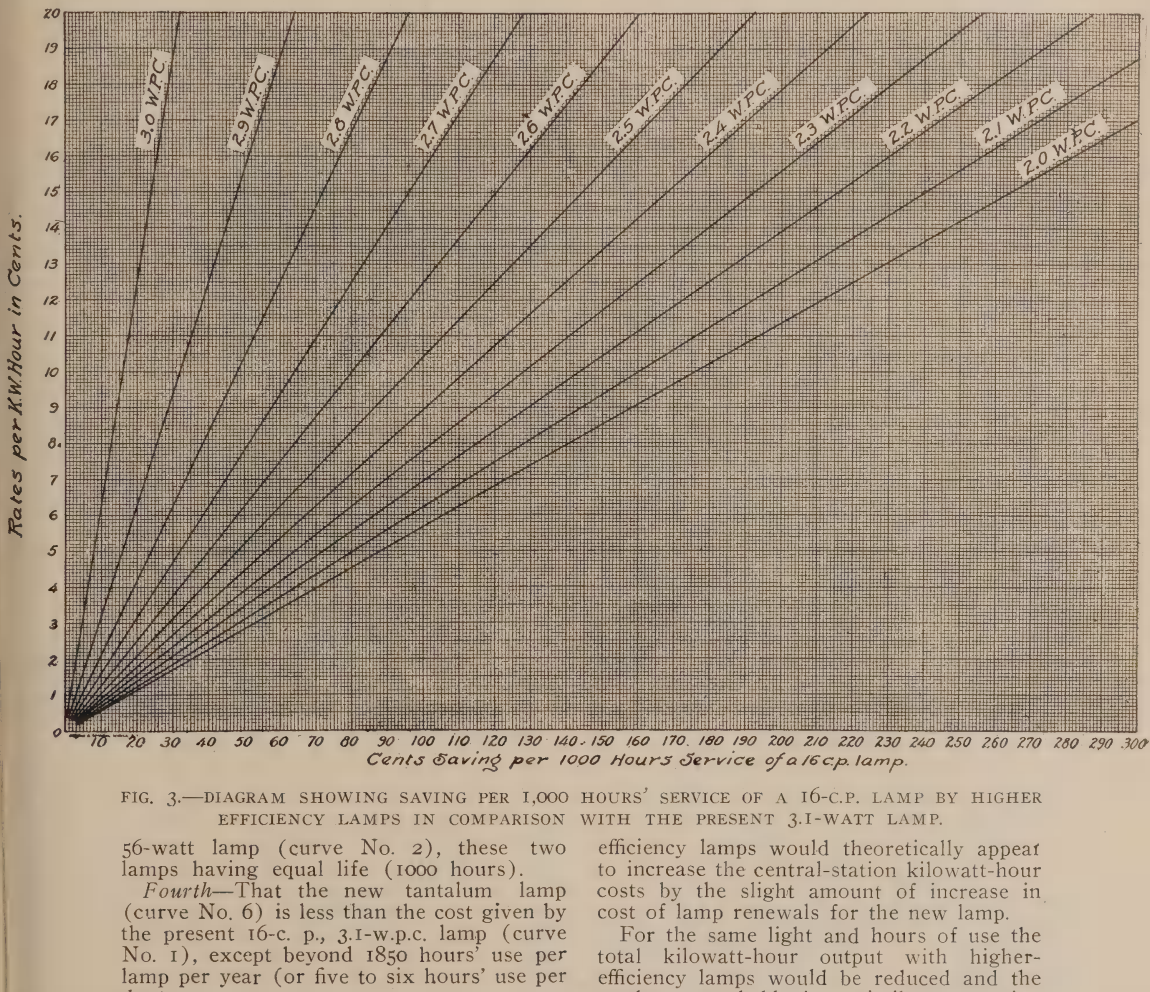


FIG. 3.—DIAGRAM SHOWING SAVING PER 1,000 HOURS' SERVICE OF A 16-C.P. LAMP BY HIGHER EFFICIENCY LAMPS IN COMPARISON WITH THE PRESENT 3.1-WATT LAMP.

whether it be sold in high or low-efficiency lamp units (or in high or low candle-power units), except in cost of lamp renewals.

From the station-cost standpoint, therefore, the logic of the situation would seem to point to the use of the lamp of the lowest renewal cost, *i. e.*, the extreme of low-efficiency lamps.

Why then should not this course be followed, and instead of developing a higher-efficiency 2.5-w.p.c. lamp to replace our present 3.1-w.p.c. lamp, why should not central-station companies adopt a 4-w.p.c. lamp, or a 5-w.p.c. lamp? Simply because the central-station-cost standpoint is not the correct basis on which to determine the proper efficiency of lamps where light is sold by the kilowatt-hour. It neglects to consider the effect upon the customer and the equivalent to a 20 per cent reduction in rates.

This value is, in a measure, of course, conjectural, as it can not be fully and definitely determined, but it should be none the less an actual and positive value.

The proposition simply stated is:

The new lamp will enable central stations (now on a free-renewal basis), by increasing their total expense only about one per cent, to give an equal volume of light at 20 per cent lower cost to their consumers, or 25 per cent more light for an equal expenditure.

The value of this improvement in service in meeting and resisting competition, in adding desirable business, in improving the load factor and in increasing net earnings —this is the important point of the whole

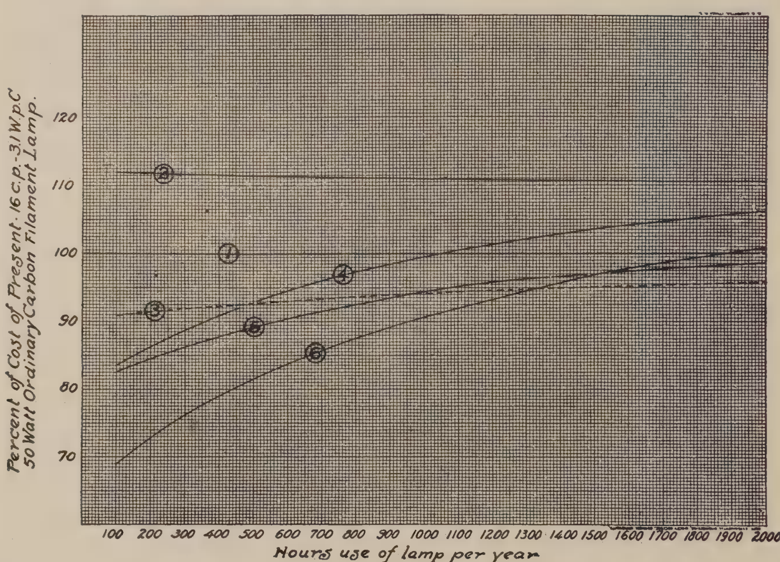


FIG. 4.—CURVES SHOWING RELATIVE COST OF PRODUCING A CANDLE-HOUR OF LIGHT WITH LAMPS OF DIFFERENT EFFICIENCIES. EXPRESSED IN PER CENT. OF COSTS GIVEN WITH PRESENT 16-C.P., 3.1-W.P.C., 50-WATT LAMPS.

selling end of the business. Whether a central station supplies free lamp renewals or not, and whether its costs are thereby changed or unaffected, the success of the business demands the lowest practicable cost to consumer—that is, it requires the use of high-efficiency lamps—of that efficiency which gives the lowest cost of light (including power and lamp renewals) at the rate paid.

THE CONSIDERATION DETERMINING THE VALUE.

The value, then, of the new 2.5-watt lamp (or any higher-efficiency lamp) lies in the general stimulus it will give to the growth of electric light service resultant from the 20 per cent improvement in efficiency for the same candle-power (or a 25 per cent increase in light for the same wattages), question, which should be fully discussed from the viewpoint and experience of central-station managers.

WHAT DETERMINES THE DESIRABLE LAMP EFFICIENCY.

It will assist here perhaps to consider the general question of what constitutes the best efficiency for central-station service. In my paper on the subject of efficiencies before the 1902 convention I stated the following:

"The best efficiency for central-station service is the one securing the greatest amount of net earnings. Net earnings are the product of per cent of profit by amount of business. There is a point of balance between these two factors at which their product, the net earnings, becomes a maximum.

Cost of 1,000 Candle-Hours of Light in Cents.
with different efficiencies at various rates per kilowatt-hour.

Rates per Kw.-Hr. in Cents.	3.5 W.P.C.	3.3 W.P.C.	3.1 W.P.C.	3.0 W.P.C.	2.8 W.P.C.	2.7 W.P.C.	2.6 W.P.C.	2.5 W.P.C.	2.4 W.P.C.	2.3 W.P.C.	2.0 W.P.C.
1	3.5	3.3	3.1	3.0	2.8	2.7	2.6	2.5	2.4	2.3	2.0
2	7.0	6.6	6.2	6.0	5.6	5.4	5.2	5.0	4.8	4.6	4.0
3	10.5	9.9	9.3	9.0	8.4	8.1	7.8	7.5	7.2	6.9	6.0
4	14.0	13.2	12.4	12.0	11.2	10.8	10.4	10.0	9.6	9.2	8.0
5	17.5	16.5	15.5	15.0	14.0	13.5	13.0	12.5	12.0	11.5	10.0
6	21.0	19.8	18.6	18.0	16.8	16.4	15.6	15.0	14.4	13.8	12.0
7	24.5	23.1	21.7	21.0	19.6	18.9	18.2	17.5	16.8	16.1	14.0
8	28.0	26.4	24.8	24.0	22.4	21.6	20.8	20.0	19.2	18.4	16.0
9	31.5	29.7	27.9	27.0	25.2	24.3	23.4	22.5	21.6	20.7	18.0
10	35.0	33.0	31.0	30.0	28.0	27.0	26.0	25.0	24.0	23.0	20.0
11	38.5	36.3	34.1	33.0	30.8	29.7	28.6	27.5	26.4	25.3	22.0
12	42.0	39.6	37.2	36.0	33.6	32.4	31.2	30.0	28.8	27.6	24.0
13	45.5	42.9	40.3	39.0	36.4	35.1	33.8	32.5	31.2	29.9	26.0
14	49.0	46.2	43.4	42.0	39.2	37.8	36.4	35.0	33.6	32.2	28.0
15	52.5	49.5	46.5	45.0	42.0	40.5	39.0	37.5	36.0	34.5	30.0
16	56.0	52.8	49.6	48.0	44.8	43.2	41.6	40.0	38.4	36.8	32.0
17	59.5	56.1	52.7	51.0	47.6	45.9	44.2	42.5	40.8	39.1	34.0
18	63.0	59.4	55.8	54.0	50.4	48.6	46.8	45.0	43.2	41.4	36.0
19	66.5	62.7	58.9	57.0	53.2	51.3	49.4	47.5	45.6	43.7	38.0
20	70.0	66.0	62.0	60.0	56.0	54.0	52.0	50.0	48.0	46.0	40.0

"The largest profits are not secured by exacting the highest per cent profit, but, on the contrary, are generally secured by low prices and small per cent of profit, thereby increasing the gross business and swelling the total profit. In other words, we are concerned not so much as to the cost of our commodity (costs may be, and frequently are, increased with advantage) ; no so much with per cent of profit, but chiefly with so fixing the selling price, and pushing the business as to increase the sales to the point of securing the maximum profit.

"Applying this idea to the question of lamp efficiency, we would say that the most desirable efficiency is not the efficiency which will return the highest per cent of profit from customers; but rather is it that efficiency which for any given rate will secure to the electric lighting company the greatest amount of profit, swelling the gross profitable business, not only by augmenting the number of lamps connected, but also by increasing the average hours of use so as to bring in the fullest net returns."

It is particularly in the improvement in load factor through increased hours of use resulting from reduced costs of lighting that central-station companies can look to for the improvement of their net earnings.

It is desired, therefore, that this discussion bring out what is the improvement of load factor resulting from reductions in rates or their equivalent. The general effect of reduction in rates should cause a broadening of load peaks and consequent material improvement in load factor. This would seem to be so, because if the cost of electric lighting is reduced to an equality with gas and other illuminants, it should insure a more extended use of electric light fully equal to that obtained with any other illuminant.

THE EFFECT ANALYZED.

To guide the discussion on this question, the accompanying exhibit (Exhibit A), page 18, has been prepared, which presents in table form a clear analysis of the effect produced by the introduction of higher-efficiency lamps for an assumed set of conditions relating to candle-power of lamp, number of lamps demanded and hours' use per lamp, upon,—

First—Station operation.
Second—Lamp-renewal costs.
Third—Central-station income.

Exhibit A gives the results for the general case and Exhibit B the actual effects in the specific case of a given central station.

The table No. A-3 in this exhibit shows clearly the advantages of the lamp-hour rate of those rate systems like that of Mr. Henry L. Doherty, having a combination flat meter rate with a charge per lamp. All such rate systems derive positive, deducible advantage from the introduction of the higher-efficiency lamp.

ADVANTAGES OF A LAMP-HOUR AND CANDLE-HOUR RATE.

This clearly shows the advantage of supplementing the pure kilowatt-hour meter rate with a charge per lamp in some form or other. The merits and demerits of this as a general proposition I will leave to be decided by experts on rate questions, but it is patent that a central station can not reap the full benefits of any improvement in lamp

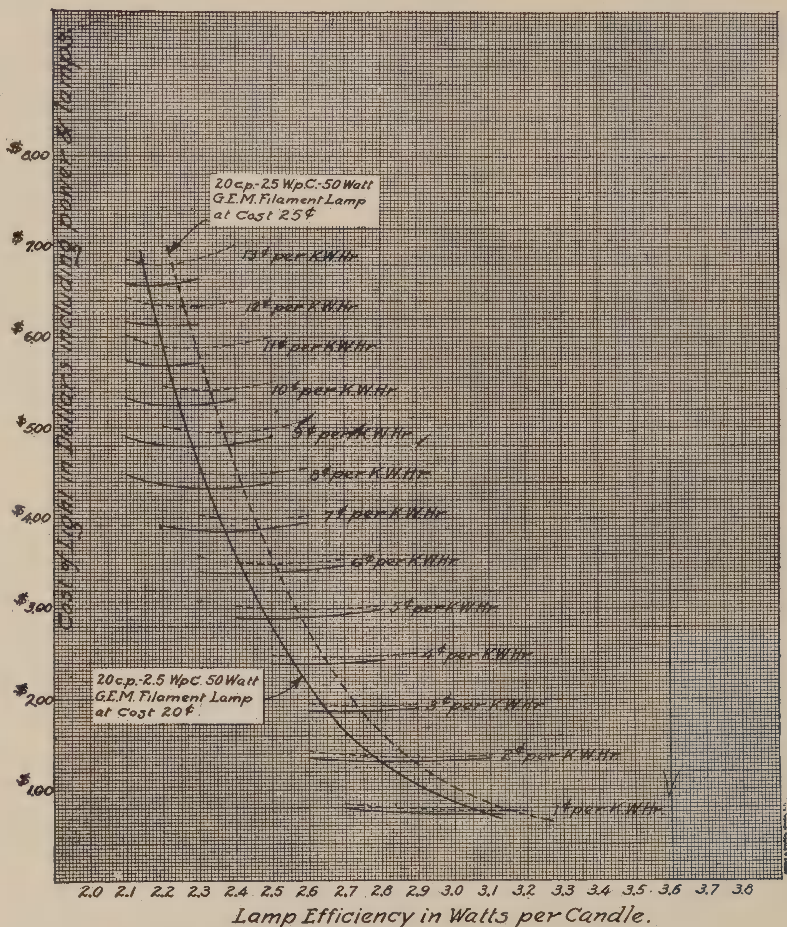


FIG. 5.—CURVES GIVING MINIMUM COSTS OF LIGHTING (INCLUDING POWER AND LAMP RENEWALS) WITH THE NEW GEM-FILAMENT, 50-WATT, 20-C.P. LAMP AT DIFFERENT EFFICIENCIES AND AT DIFFERENT RATES PER K.W.-HOUR.

efficiency unless charges in some way are made to include the lamp or candle-hour value. The new high-efficiency lamp enables us to produce a given amount of light cheaper, as already indicated, but theoretically increases the cost for a given amount of kilowatt-hours. As a result, the benefit apparently all goes to the consumer with little or no return to the lighting company, if we exclude the stimulating effect upon business.

The values in Tables IX and X well illustrate this point. Table IX shows the cost per 100 candle-hours of light to consumers for different lamp efficiencies and rates per kilowatt-hour. Table X shows various values for higher-efficiency lamps as compared to present lamps. These tables bring out the benefit of higher-efficiency lamps to the consumer buying on the kilowatt-hour basis, in the reduction in cost per 1000 candle-hours of light. As shown by column No. 5, Table X, this cost is only 20 cents for the tantalum lamp as compared with 31 cents for the present 16-c.p., 50-watt lamp at 10 cents per kilowatt-hour rate. Also by the last column of Table X we see that the income from the tantalum lamp on the candle-hour basis is 50 per cent greater than on the kilowatt-hour basis.

KILOWATT-HOUR NOT THE CORRECT BASIS FOR LAMP-RENEWAL COSTS.

Table X also shows that the kilowatt-hour cost basis is not a fair one for lamp-renewal costs. This is true because it is inevitable that with the decrease in total wattage of lamps the renewal costs per kilowatt-hour should increase in the same proportion. For example, a 16-c.p. lamp of one watt per candle or 16 watts total, would, at the same price per lamp, cost three times as much per kilowatt-hour as the present lamp.

To keep renewal costs per kilowatt-hour

unchanged would require that the costs of higher-efficiency lamps should diminish in the same ratio as the efficiency is increased. This can not logically be expected, as improved lamps will tend to cost more rather than less. It would be correct practice, therefore, to drop the kilowatt-hour as a basis for lamp-renewal costs and take the cost per candle or equivalent light.

THE STANDARD FOR THE NEW LAMP.

Returning to Exhibit A, a careful study of the tables thereunder shows that the minimum disturbance to central-station operating results, renewal costs, and particularly to the company's income, is given by a lamp of 25 per cent increased candle-power, *i. e.*, the new 20-c.p., 50-watt lamp. It has been decided, therefore, to standardize on this lamp, and to make the new standard lamp (to replace the present 16-c.p., 3.1-w.p.c. lamp) a 20-c.p., 2.5-w.p.c. lamp with the same total wattage of 50 watts, and not a 16-c.p., 40-watt lamp.

The same reasoning would indicate that in the case of the tantalum lamp a 25-c.p., 50-watt lamp would be advisable.

Besides the advantages shown by Exhibit A, there are the following good reasons for this plan.

A higher candle-power incandescent lamp is needed to cope with competition of the Welsbach gas light, whose candle-power value is high.

Many consumers, particularly the desirable consumers, will spend a given amount of money for light in any event, and it is rational to anticipate this fact by giving them the increase in the candle-power of the lamp, instead of necessitating an increase of installation to accommodate more lamps of the present candle-power.

The plan follows the practice adopted by gas companies at the time of the introduction of the Welsbach lamps, where the improvement in efficiency is given in a very large measure in increased candle-power, which practice has proved so satisfactory to the gas business.

The plan gives the central-station company the same output per consumer as at present given, thus avoiding the necessity of having to increase the number of consumers or the number of lamps connected per consumer, which would necessitate a possible increase in distributing expense.

The plan keeps down lamp-renewal cost per kilowatt-hour.

The new 20-c.p., 50-watt lamp, comparable in life with the present 16-c.p., 3.1-w.p.c., gives a derived unit (by lowering the voltage 4 per cent) of 16-c.p., 45 watts total with 1000 hours' life—a comparable lamp to the present 16-c.p., 3.5-w.p.c. lamp—thus providing the new lamp for conditions requiring such lamp life.

The proposed plan does not contemplate dispensing with lower candle-powers and wattages. There will be smaller units—30 watts, 20 watts—and other sizes made with the new GEM filament. The tendency will be, however, to go above and below the present 16-c.p. standard.

THE NEW LAMP RATING AND LABEL.

This new label possesses many interesting features. It will be noted that only total wattage and voltage markings are given. Candle-power values will not be shown, as these have become confusing, due to the use of the term in so many varied ways: Candle-power is used to express concentrated values due to reflection from supporting frames in such lamps as the Nernst; to express values given by reflectors used with the lamp as in the case of the Meridian and General Electric units, and so forth. Candle-power values have as a result of this indefinite use become misleading and confusing, and it has been considered desirable to omit them from the lamp label and to give them only when required, and then fully and accurately defined as "mean horizontal," "mean spherical," "values with a given form of reflector," and so forth.

Inasmuch as the sale of electric light is made largely on the watt-hour basis and not on the candle-power, the proper unit is really watts per lamp, instead of candle-power. This practice is along the lines of gas practice, where the burners are generally rated in cubic feet consumption, rather than in candle-power values.

Further good reasons for this plan are as follows:

It permits the adoption of even total watt values per lamp, as 50-watt, 30-watt, 25-watt, 10-watt, *et cetera,* instead of the fractional values now given.

The filament is rated to burn at an even degree of heat or incandescence, thus insuring more uniform performance as regards individual lamps.

The appearance of the lamps in service should be more uniform, as a slight variation in candle-power is not as noticeable as a variation in degree of incandescence or efficiency.

By eliminating the candle-power from the label, and absolutely fixed standards of candle-power as an essential to quality or good service, and by substituting therefor only watts per candle as a comparative basis, which standard can be varied to suit varying conditions, it will be possible for central stations to gradually advance their standard of efficiency from time to time to meet changing conditions.

It will be observed that the new lamp

label has three voltage markings shown arranged in a vertical column in steps of two volts apart. These voltages are known as "top," "middle" and "bottom" voltages, or first, second and third voltages.

Customers requiring lamps of maximum efficiency—2.5-w.p.c.—will order lamps whose "top" labeled voltage or first voltage corresponds to the circuit voltage.

Customers requiring a lamp of slightly lower efficiency—2.65-w.p.c.—will order lamps whose "middle" labeled voltage or second voltage corresponds to the circuit voltage.

Customers requiring lamps of still lower efficiency—about 2.8-w.p.c.—should order lamps whose "bottom" labeled voltage or third voltage corresponds to the circuit voltage.

For example, take a lamp labeled as shown in Figure 9.

This lamp on a circuit of 112 volts will be burning at maximum efficiency 2.5-w.p.c. and full wattage of 50 with a useful life of about 500 hours; or

The same lamp on a circuit of 110 volts will give 10 per cent less candle-power with an efficiency of about 2.65 w.p.c., total watts about 47.5, and a useful life of about 750 hours; or

The same lamp on a circuit of 108 volts will give 20 per cent less candle-power with an efficiency of about 2.8-w.p.c., total watts about 45, and a useful life of about 1000 hours.

By adopting this method as a standard rating, all lamps can be more exactly suited to existing conditions than on the present basis of rating.

THE GENERAL POLICY FOR THE NEW LAMPS.

What shall be the general policy for central stations to adopt with regard to the new lamp?

Accepting the standard agreed upon, namely, 50-watt, 20-c.p. lamp, central stations can have their option of adopting the new lamp either at "top, "middle" or "bottom" labeled voltage, as described in the foregoing description of label, and of thus giving their consumers

The highest efficiency available with total output unaffected, or

Lower efficiencies with reduction of output and lessened renewal costs resulting from longer life.

The change in renewal costs is given in Table X, column No. 5 (see also Table II and Figure 2, which show renewal costs of the present and new lamps per kilowatt-hour at various efficiencies).

Progressive practice should lead all central stations now using the 3.1-w.p.c. lamp to adopt in its stead the new 20-c.p., 2.5-w. p. c. lamps at full efficiency, thereby keeping their watt consumption per lamp the same as at present. On this plan for the same useful life their renewal costs would remain unchanged on the correct basis of cost per candle, or on the kilowatt-hour basis would be increased by the small amount of 0.16 cent per kilowatt-hour.

Central-station companies at present using 3.5-w.p.c. lamps could adopt one of the following:

	Reduction in Watt Consumption per Lamp.	Change in Lamp Renewal Cost per Kw.-Hour.
20-c.p., 50-watt lamp (top labeled voltage).	6.0 watts or 10.7 per cent.	+ 0.514 cent
18-c.p., 2.65-watt lamp (middle labeled voltage)	7.5 watts or 13.4 per cent.	+ 0.139 cent.
16-c.p., 2.8-watt lamp (bottom labeled voltage)	10.0 watts or 18.0 per cent.	+ 0.158 cent

The middle labeled voltage step would seem desirable for the present 3.5-w.p.c. station, as it shares the improvement with the consumer, giving 12 per cent more light, with 15 per cent less wattage. Present 3.5-w.p.c. lamp-renewal costs are very low, and most stations could aoffrd the slight increase therein for the new lamp. With the present lamps there appears to be need of an intermediate efficiency between 3.5 and 3.1 watts per candle, *i. e.*, about 3.3 watts per candle. The new lamp at middle label voltage gives equal life to a present 3.3-w.p.c. lamp and should therefore satisfy this intermediate need.

EFFICIENCY OF NEW LAMP, GIVING MINIMUM LIGHTING COSTS.

The minimum cost of lighting to the consumer paying for light on the kilowatt-hour basis at different rates will be secured with that efficiency which makes the sum of lamp renewals and cost of current a minimum. Estimating these costs as shown in my previous paper on efficiencies, we have the values for the new GEM lamp given in Table VIII and Figure 7. This table and curves show that for all rates above 5 cents per kilowatt-hour a consumer would obtain his light at a minimum cost, including cost of purchasing his own renewals by using the new 2.5-w.p.c. lamp.

The accepted practice supplies lamp renewals free and saves the consumer this part of the expense. It would seem, therefore, that this full efficiency of 2.5 watts per candle would be the desirable one for central-station companies to supply, because at any lower efficiency the consumer could afford to buy his own lamps and would save money by so doing. Enlightened and progressive central-station practice finds bene-

fit in making the consumer's interest its own, and should therefore supply the lamp that secures a minimum lighting cost, *i. e.*, the new 2.5-w.p.c. lamp.

THE POLICY FOR LAMP RENEWALS WITH HIGHER-EFFICIENCY LAMPS.

The control of lamp renewals by central-station companies is shown by both practice and theory to be a necessary condition for securing and insuring the best lighting results. The cost of lighting, of which the lamp renewal is a part, can unquestionably be made less to consumer when the central station purchases and supplies the lamp. This is so because the central-station company purchases intelligently where the average consumer purchases unintelligently, generally choosing a poor-quality, long-life, low-efficiency lamp and paying therefor the highest retail price.

Experience shows that central stations must supply the lamps to insure the use of lamps of the maximum efficiency and provide lighting service at the minimum cost to consumers. In practice we find that where the consumer is left to purchase his lamp, the first cost and life of the lamp becomes of greater importance than the efficiency of lamp and consequent cost of light. In proof of this we note that there are to-day no 3.1-w.p.c. lamps used on central-station circuits in this country except where the companies furnish renewals. It is well known that where the practice prevails of making the consumer buy his own lamp, as in Europe, lamps of only the lowest efficiencies are used, namely, 4 and 5 watts per candle, and that there is little demand for any higher efficiencies or inducements held out to the lamp manufacturers to supply such. We may conclude, therefore, that the new 2.5-w.p.c. lamp at full efficiency would not be adopted by the average consumer were he left to purchase his own lamp renewals.

To secure the introduction and use of higher-efficiency lamps it is necessary for central-station companies to furnish renewals. If central-station companies agree that it is very desirable to have the new lamp of the same total wattage as the present lamp in order that income may not be impaired, then it becomes necessary for the lighting company to furnish renewals of this lamp to their consumers to secure its adoption.

This seems to me a strong argument for as full control of the new lamps as is now the case with the present lamps; that is a free renewal supply. In any event, central stations should supply the new lamps to their customers at as low a cost as possible to replace the present carbon-filament lamp on some one of the following plans:

First—Where the rates are fair or well maintained with some available margin, the additional costs of renewals, which, as shown herein, are very slight, can be absorbed in the present rates and the new lamps supplied free on the same basis as the present lamps.

Second—Where rates are very low with no margin available, the rates can be increased by the small margin necessary to cover the slightly increased cost of lamp renewals. On rate systems which charge by lamp-hour, lamp-month or lamp-year, this increase can be readily made. On regular watt-meter systems it can be effected by a slight increase in the kilowatt-hour rate.

Third—Where rates can not be increased by reason of laws in force and otherwise, or where rates are low, with no margin available for this additional renewal expense, it would appear to be necessary to charge customer an additional sum per lamp, represented by the difference between the cost of the new lamp and the present lamp.

In general for the new GEM-filament lamp it is to be hoped that central stations will adopt the first plan and thus insure the use of the higher-efficiency lamps.

RENEWALS WITH THE TANTALUM LAMP.

For lamps like the tantalum, costing materially more than the present lamp, the second or third plans may be adopted, thus providing consumers with the lamps at the minimum cost by charging only the additional cost therefor. Assuming a price for the tantalum lamp of 75 cents retail, 60 cents to central stations now buying at 16 cents, and with a lamp life of 800 hours on direct current, the renewal cost will be 1.5 cents per kilowatt-hour, which is 0.86 cent more than present 3.1-w.p.c. lamp-renewal costs.

Or consumers can be supplied with renewals of tantalum lamps at the increased cost over present lamps. As compared to present 3.1-w.p.c. lamps at 16 cents—the life of which (500 hours) is five-eighths that of the tantalum (cost 60 cents), we find the relative cost of the tantalum lamp to be sixty times five-eighths, or 37.5 cents. Deducting cost of present lamp (16 cents), gives 21.5 cents, or, in round figures, 25 cents more for the tantalum lamp. This is about the price of a Welsbach mantle. Electric companies could therefore meet Welsbach competition with the tantalum lamp by supplying renewals at the same price as Welsbach mantles—without increasing renewal costs over free renewals with present 3.1-w.p.c. lamps.

THE EFFECTS IN THE ANALOGOUS CASE OF THE WELSBACH LAMP.

The general effects of the introduction of high-efficiency lamps can perhaps best be determined by referring to the results of an analogous case in the gas business. We all well remember what consternation was caused among gas companies with the advent of the Welsbach mantle gas lamp several years ago. The improvement produced by this lamp was a much greater one rela-

tive to the old gas burner than that of the new lamps in comparison with the present lamps. It was feared generally among gas companies that the Welsbach lamp would bankrupt them, and the majority of gas companies looked upon this lamp with such great disfavor that for a long time they would not undertake to supply them to their customers. How different the actual results were from those expected we all well know and the present development of gas lighting attests. Far from being detrimental to the gas business it was its salvation and gave it a new lease of life in the lighting field, proving substantially the benefit to a lighting company of benefiting the consumer.

GENERAL CONCLUSION.

Why should not electric lighting companies derive similar benefits from the introduction of higher-efficiency incandescent lamps? It would appear illogical to expect otherwise, or that any improvement in efficiency of the electric lamp would not yield central stations as desirable and proportionately as full returns as those obtained in the gas business.

The demand for more light is insistent, and its use appears to increase with every improvement in lighting devices. The electric lighting industry has suffered for the want of higher-efficiency lamps, its growth has been retarded, its possibilities curtailed.

Now with the advent of incandescent lamps giving improvements of 20 and 30 per cent and the promise of still greater gains, the restrictions of the past will be gradually removed and the industry is sure to expand and develop to the full measure of the opportunity the improvements afford.

There should be no question on this point or of the wisdom of supplying consumers electric light at the lowest possible cost by the employment of high-efficiency lamps and the adoption of a profitable low-rate system of charges—thus giving electric lighting the freest rein and enabling it to distance its competitors and maintain that supremacy which it rightly should hold in the lighting field.

These considerations should prompt each and every central-station manager to enthusiastically welcome and promptly utilize the new improved lamp and give the benefit to his consuming public from whom his company's business is derived and upon whom its stability and success depends.

COMPARISON VALUES OF NEW HIGHER-EFFICIENCY LAMPS AND PRESENT LAMPS.

	1	2	3	4	5	6	7	8	9	10	11	12
GEM - filament, 40-watt lamp, 16 - c.p., 2.5-w.p.c.	500	20	0.04	25.0	400.0	25c.	1.0 c.	0.04 c.	2.5 c.	$4.00	$5.00	$5.00
Ordinary - carbon filament, 50-watt lamp, 16 - c.p., 3.1-w.p.c.	500	16	0.05	20.0	320.0	31c.	0.64c.	0.032c.	2.0 c.	5.00	5.00	5.00
GEM - filament, 50-watt lamp, 20 - c.p., 2.5-w.p.c.	500	20	0.05	20.0	400.0	25c.	0.8 c.	0.04 c.	2.0 c.	5.00	5.00	6.24
GEM - filament, 45-watt lamp, 16 - c.p., 2.8-w.p.c.	1000	20	0.045	22.2	355.5	28c.	0.44c.	0.16 c.	1.25c.	4.50	5.00	5.00
Ordinary - carbon filament, 56-watt lamp, 16 - c.p., 3.5-w.p.c.	1000	16	0.056	17.84	285.4	35c.	0.3 c.	0.02 c.	1.0 c.	5.60	5.00	5.00
Tantalum - filament, 50-watt lamp, 25-c.p., 2.0-w.p.c.	800	60	0.05	20.0	500.0	20c.	1.5 c.	0.075c.	3.0 c.	5.00	5.00	7.80

Col. 1.—Useful life of lamp in hours. Col. 2.—First cost of lamp in cents. Col. 3.—Kilowatts per lamp. Col. 4.—Lamp-hours per kilowatt-hour. Col. 5.—Candle-hours per kilowatt-hour. Col. 6.—Cost of 1,000 candle-hours of light at 10c. per kilowatt-hour. Col. 7.—Lamp renewal costs per kilowatt-hour. Col. 8.—Lamp renewal costs per lamp-hour. Col. 9.—Lamp renewal costs per 1,000 candle-hours. Col. 10.—Income per lamp per 1,000 hours' service on kilowatt-hour basis at 10c. per kilowatt-hour. Col. 11.—Income per lamp per 1,000 hours' service on lamp-hour basis at ½c. per lamp-hour. Col. 12.—Income per lamp per 1,000 hours' service on candle-hour basis at 31.2c. per 1,000 candle-hours.

LONG FLAME ARC LAMPS

By Leonard Andrews.

PRESENTED TO THE INSTITUTION OF ELECTRICAL ENGINEERS (ENG.) APRIL 26 (ABRIDGED).

Until comparatively recently, all tests and experiments made with arc lamps appeared to show conclusively that to obtain the highest efficiency the length of the arc should not exceed 3 mm. or 4 mm. Mrs. Ayrton shows that "almost the whole of the increased power that has to be supplied to the arc when it is lengthened is swallowed up by the mist, and is practically wasted." The following table of comparative efficiencies appears to show, however, that, whilst increasing the length of the arc beyond 3 mm. or 4 mm. does tend to reduce the efficiency of arc lamps with coaxially arranged pure carbons, this rule does not apply to many of the long flame arc lamps having inclined downward-feeding carbons which have now begun to be very generally used.

Taking the mean of the results given by different authorities, and reducing them all to a common basis by making the necessary corrections for globes and different standards of illumination, it appears that the relative efficiencies expressed in mean hemispherical British candle-power of the different types of lamps are approximately as follows:

	C.P. per amp.	C.P. per watt.
Ordinary open arc........	82	1.54
Enclosed arc.............	55	0.77
Carbone H.T. arc........	200	2.24
Chemical carbon arc......	259	5.80

Returning to the question of long arcs versus short arcs, it is an interesting fact that all the very marked improvements that have been made in arc lighting during recent years have been effected by the use of arcs from 10 mm. to 15 mm. in length, and investigation shows that the great improvement in efficiency is directly or indirectly due to this increased length.

The improvements effected may be briefly summarized as follows: (*a*) The formation of the positive crater in such a position that none of the light emitted by it is obstructed by the negative carbon. (*b*) The impregnation of the carbons with metallic salts, thereby rendering the flame highly luminous.

It is well known that the maximum illumination obtainable from a pure carbon arc lamp in any direction is proportional to the area of the positive crater visible in such direction, plus the light emitted by the red-hot portions of the carbons, the white spot on the negative, and the flame or arc mist; and since the area of the crater is approximately proportional to the current and is not appreciably increased by an increase of voltage, it would appear at first sight that to expend energy on an increase of voltage must tend to decrease the efficiency. It must be remembered, however, that for all practical purposes it is not so much the actual area of the crater that determines the useful efficiency of an arc as the area visible at any angle below the arc. Mr. Trotter has shown that if none of the light from the positive crater is intercepted, then the candle-power from this source at any angle may be represented by the radius vectors of a circle drawn to such a scale that the diameter of the circle is proportional to the candle-power measured directly facing the crater.

Many attempts have been made during recent years to solve this (at first sight) simple problem. Some of these attempts have been directed towards increasing the length of the arc of an ordinary arc lamp, with the idea of thereby allowing more light to escape. In some notes on Angold arc lamps published by the General Electric Co. it is stated "an increase of voltage lengthens the arc and decreases the shadow of the negative carbon, thus giving more light at a greater efficiency, but the practical limit is reached at 45 volts, when the unsteadiness from flaring counterbalances the improvement in light." Mrs. Ayrton shows, however, that no useful object is obtained by increasing the length of an ordinary arc beyond 3 mm. or 4 mm., as the light absorbed by the lengthened arc mist exceeds the additional light which escapes unintercepted by the negative carbon.

Various other attempts have been made to get an unobstructed positive crater by the use of inclined carbons, but all these experiments appear to have been carried out with voltages of from 40 to 45 volts across the arc, and at these pressures the crater forms on the side of the positive carbon between it and the negative, instead of at the tips, and consequently, at pressures of less than 60 or 70 volts, more light is intercepted by the negative carbon with inclined carbons than with carbons arranged in the ordinary way. Mr. Carbone appears to have been the first to suggest that the solution of the difficulty was the use of inclined carbons combined with a voltage of from 80 to 90 volts across the arc. Whilst the mere appreciation of the advantage of high voltage with inclined carbons constitutes a marked advance in arc lighting, further invention was necessary to render the system practicable. Carbone also discovered a method of controlling the long arc without flickering, and succeeded in obtaining a form or shape of flame which reduces to a minimum the absorption of the light from the crater by the arc mist.

Fig. 1 shows the ends of carbons and the economizer of a "Carbone" arc lamp. The arrangement of these appears to be, at first sight, precisely similar to that of all

other flame arc lamps. The essential difference, however, lies in the magnetic control of the arc. Any attempt to repel the arc to the tips of the carbons by means of a moderately strong concentrated magnetic field produces an effect somewhat similar to that of a blowpipe, tending to blow the arc into a bluntly-pointed flame, extremely difficult to keep steady, and of a shape that increases the length of the arc mist to be traversed by the light emitted by the positive carbon.

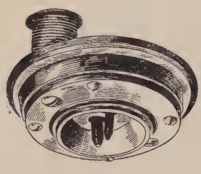


FIG. 1.

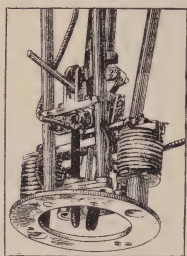


FIG. 2.

The Carbone method of controlling the position of the arc is shown in Fig. 2. This consists of a closed iron magnetic circuit, the only field affecting the arc being that due to magnetic leakage from this closed circuit. The chief leakage will obviously be from the ends of the cores carrying the exciting solenoids. The magnetic circuit from the ends of these cores is completed through the iron ring. This ring, which also serves to hold the economiser in position, is fixed concentrically with the arc slightly above the plane normally occupied by the tips of the burning carbons. Holes are drilled in the ring midway between the points to which it is fixed to the core, thereby increasing the magnetic reluctance, and causing further leakage, at points approximately at right angles to the cores. The result is a weak hemispherically-shaped leakage field of just sufficient strength to maintain the craters at the tips of the carbons, the shape of the flame covering the mouth of the economiser somewhat resembling that of a soap bubble covering the bowl of a tobacco pipe under very slight pressure.

Turning now to the second improvement effected in arc lighting, namely, that due to the impregnation of the carbons by metallic salts, even greater radical departures from hitherto accepted principles are found. It would appear, that of the total candle-power of 2,750 hemispherical candle-power emitted by a 10 ampere chemical carbon arc, less than 700 candle-power is emitted by the positive crater. Whilst, therefore, the high efficiency of this type of arc is in a measure due to the formation or the craters in such a position that none of the light from the positive crater is intercepted by the negative carbon, it is evident that it is only partially due to this cause. When the shell on the side of the positive carbon nearest to the negative carbon has burnt away, the crater gradually travels round to the opposite side of the carbon. This causes considerable difference in the pressure across the arc, the total variation sometimes amounting to as much as 15 per cent.; that is to say, the voltage will increase from 40 volts, when the crater is on the near side of the positive carbon, to 46 volts when it is on the far side. It is interesting to note that, owing apparently to the lower resistance of a chemical carbon arc, the craters can be retained at the tips of the carbons with a very much lower voltage than is required for a pure carbon arc. Another noticeable difference between chemical carbon arcs and pure carbon arcs is to be found in the drop of potential across the positive crater.

The bulk of the light from a chemical carbon arc emanates from the flame, and is apparently due to minute burning particles in the flame which are raised to a very high state of incandescence. It has been found that the relative intrinsic brilliancy of the flame of a chemical carbon lamp is about one-third that of the positive and negative craters. It must be remembered, however, that the area of the flame visible at any angle is many times that of the crater, and the total light emitted by the flame is consequently many times that emitted by the craters.

Whilst the commercial use of chemically impregnated carbons has only come to the fore within the past two or three years, the idea is by no means new. Mr. Trotter, in his Paper before this Institution in 1892, made the following reference to the suggestion: "Several attempts have been made to improve the arc by adding volatile substances, or by introducing gas through a hollow carbon. The only good effect that can be expected is the production of a long arc, which will reduce the shadow of the lower carbon; and it is likely that the temperature of the crater will be reduced by the presence of any substance less volatile than the best carbon." It would appear from the above that the chief gain in efficiency due to the high luminosity of the flame was not then appreciated. The efficiency of a chemical carbon lamp is so very much higher than it has yet been possible to attain with any type of pure carbon arc that it might appear at first sight that the use of pure carbons would very soon cease. Unfortunately, however, the advantage from the point of view of efficiency is discounted by certain defects which render this type of lamp unsatisfactory for many purposes.

The flickering noticeable in all chemical carbon lamps cannot at present be entirely overcome, though it has been greatly reduced in recent lamps. Considerable improvement has been effected during the last

year or two in the composition of the carbons used for chemical carbon flame arc lamps. The large amount of calcium salts first proposed by Bremer and the non-conductive scoria caused a great irregularity in burning. The carbons are now usually of the composite type, consisting of three zones. The outer zone or envelope is composed of pure carbon, giving mechanical strength. The next contains carbon mixed with various salts, such as those of calcium and magnesium, and the inner soft centring core is made of the same materials less strongly compressed.

The poisonous fumes given off by the burning chemicals make the lamp unsuitable for use in a room not very efficiently ventilated, besides which these fumes are very apt to injure the mechanism of the lamp. The ash or residue from a chemical carbon arc is very much greater than from a pure high-voltage flame arc lamp. The author has obtained photographs of the ash from a 10 ampere chemical carbon arc and from a 10 ampere "Carbone" pure carbon arc after two hours' burning by placing plates of clear glass in the respective globes, these being carefully removed without disturbing the ash and used as negatives. The ash from the chemical carbon lamp was many times greater than that from the pure carbon arc. The carbons are at present considerably more costly than pure carbons. and as the globes cannot be entirely enclosed the life of the carbons is very short. The light is useless in positions where discrimination of colors is required.

Color.—The color of an artificial light is for many purposes of even greater importance than its efficiency. Considerable difference of opinion exists as to what is the best color, and this difference will probably remain so long as it is attempted to define any one particular color as the best for all purposes. For the illumination of the outsides of public buildings, theaters, etc. (especially where these are built of stone), there is nothing more effective and more pleasing than the yellow color given by the chemical carbon arc lamp. It is also the best light for penetrating a thick yellow fog. For many other purposes, however, a pure white light is generally to be preferred. What is the exact definition of the term "white light" is somewhat difficult to express. It is certainly not the violet tinted light of the ordinary arc lamp, nor is it the distinctly green light of the incandescent gas lamp. Possibly the best definition is: "A light which makes all colors appear to be exactly the same, whether illuminated by daylight or the artificial light in question." The yellow light given by the majority of chemical carbon lamps is sometimes claimed to be similar to that of sunlight. One of the best tests of this is to examine colors, or, say, a crowd of faces illuminated by one of these lamps. It will be at once apparent that the resemblance in the effect of the two lights is extremely remote.

The nearest approach to a pure white light that has yet been attained by artificial means appears to be that of the high-pressure pure carbon arc with downward-feeding inclined carbons. That it is so, however, is somewhat surprising, as it would be expected that the very long flame of the high-voltage arc would give a very violet light. The extreme whiteness of this light is referred to by Dr. Wedding in his report on the "Carbone" arc. In discussing the cause of this he says: "The spectroscope analysis shows a very wide spreading out in the violet parts of the spectrum alongside of a strong line in the yellow green. Numerous lines stand out in the violet, through which no doubt the tone of the color is called forth."

Sir W. Abney has shown that the light emitted by the positive crater of a pure carbon arc lamp is very like sunlight, but has a slight excess of orange and green rays, and a slight deficiency of blue. Notwithstanding this generally accepted fact, it is well known that the light from an ordinary arc lamp tends to make objects appear to be blue or purple, particularly when the arc is long. Mrs. Ayrton attributes this blueness to the fact that a portion of the light from the crater in passing through the flame of the arc is reflected and refracted by minute particles of incandescent carbon, and as these carbon particles absorb the red and green rays, and allow the violet rays to pass, the light emitted by the flame or carbon mist is of a deep violet color. It would appear, therefore, that if just the correct quantity of this violet light could be mixed with the direct light from the crater, which, as has been shown, is deficient in violet rays, the result would be an exact reproduction of sunlight. In the ordinary direct current arc, a large percentage of the crater light is intercepted by the negative carbon, whereas, owing to the very much larger area of the flame, comparatively little of the light from it is so intercepted. The resultant mixture, therefore, contains far more violet rays than are required to produce a pure white light.

The color effect of intercepting a portion of the light emitted by the positive crater may be shown by a simple experiment suggested by Mrs. Ayrton. If a plate of metal is interposed between the arc and a screen, the shadow of the metal will be edged with a broad band of violet light, this being the portion of the screen illuminated by the refracted light from the carbon particles constituting the arc mist.

Now it appears reasonable to argue that the interception of some of the direct rays from the positive crater by the negative carbon of an ordinary arc lamp must have the same effect upon the total color of the light as the metal screen referred to above.

The fact, therefore, that none of the crater light of the "Carbone" arc is intercepted may, at any rate partially, account for the pure whiteness of this light. It is also noticeable that the light from the flame itself is by no means so violet as that of an ordinary arc lamp. This appears to be due to the large area of the sheath of burning gases. Is it not possible that this sheath is the cause of the numerous dark lines which Dr. Wedding observed in the violet portion of the spectrum, and to which he attributes the tone of the color? Certainly the portion of the arc mist which is not sheathed by burning gases (namely, the upper portion of the hemispherically shaped flame) does emit a light which is intensely violet. This very violet light is thrown up into the mechanism between the carbons and the insulating carbon guides.

General Effect and Distribution of Light.—It is interesting to note that arc lamp designers have during recent years paid very much more attention to these points. There is no doubt that for effective lighting the globe should have the appearance of being *full* of light. The popularity that has recently been attained by several types of enclosed arc lamps is undoubtedly in a great measure due to the use of small globes, and whilst the efficiency expressed in the "mean hemispherical candle-power per watt" is considerably lower than that of the large globe open-type arc, the efficiency expressed in the "satisfaction to the general public per watt" is considerably greater. The long flame arc is particularly well adapted for use with small globes, and all flame lamps, whether of the chemical carbon type or of the high-voltage pure carbon type, always appear to give a good globeful of light. This effect is also in a great measure due to the absence of shadows resulting from the use of inclined carbons.

It must be remembered that the general public do not judge of the efficiency of any system of lighting by taking photometric tests. It would probably be much better for the electrical industry if they did. Their usual method of judging a light is, first to look at the source of light, to satisfy themselves that there is a large area of light-giving surface, and secondly to examine the ground directly below the lamp they are judging. The engineer, however, recognizes that it is of even greater importance to know what is the minimum illumination midway between lights than it is to know the maximum illumination directly below the arc.

It is well known that at least 40 per cent. of the light emitted by an arc lamp is intercepted by the opalescent globe. This waste, with ordinary arc lamps, appears to be necessary, in the first place to prevent the dazzling effect which would result from an unscreened arc fixed at a position that comes within the natural angle of sight, and in the second place to give a diffused light, or the effect of a light emitted from a large surface. Dealing first with the screening effect necessary to prevent dazzling, this need not be considered if the source of light can be placed at such a height above the ground that it does not come within the natural angle of sight. It appears, in fact, that we might take a lesson from Nature. At midday, in midsummer, when the sun is directly above our heads, and consequently not within the natural angle of sight, the light emitted by it is comparatively unscreened, and is blinding to look at, even for a moment. When the sun is setting, however, and is consequently directly within the angle of sight, such a large percentage of its light is intercepted or screened by the atmosphere that we are able to distinguish objects clearly which are in a direct line between ourselves and the sun.

Owing to the fact that with an ordinary arc the bulk of the light is emitted at angles of less than 60 deg. below the horizontal, it is necessary to place such lamps comparatively near the ground to get efficient results from them. This objection does not, however, apply to long-flame arc lamps, in which the maximum light is directly below the arc. It appears, therefore, that for many purposes, such, for instance, as for lighting large buildings, where the source of light can be placed 30 ft. or 40 ft. above the ground, it is unnecessary to use densely-obscured globes. It is suggested that for this purpose long-flame arc lamps should be used, fitted with globes of which the lower half is unobscured.

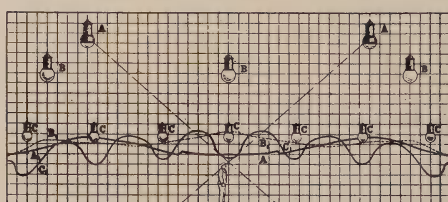


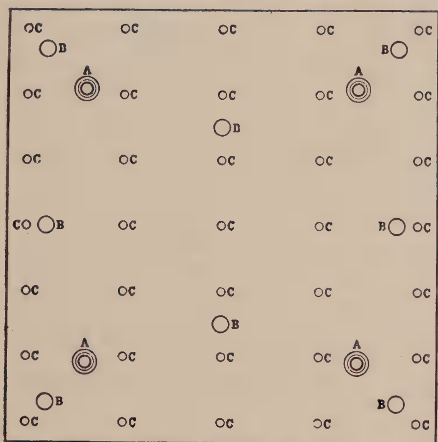
FIG. 3.

Curves A_1, B_1 and C_1, Fig. 3, show respectively the illumination per square foot on the floor space of a room illuminated by 800-watt high-voltage pure-carbon long-flame arc lamps, with globes half unobscured at A, A, 25 ft. above the ground, and with similar lamps fitted with globes, absorbing 40 per cent. of the light at B, B, B, 20 ft. above the ground, and with 460-watt ordinary enclosed arc lamps at C, C, C, etc., 10 ft. above the ground. It will be seen that the mean illumination is approximately the same in each case, but that a considerable saving of energy is effected by using unobscured flame lamps 25 ft. above the floor level. It is also noticeable that the distribution of light is much more

even with the few lamps placed high up than with the larger number of lamps nearer the floor. Fig. 24 shows the arrangement of lamps required to produce a given mean illumination over a given floor space, the energy expended with the three systems being respecitvely as follows:

	Watts.
Four 800-watt unobscured high-voltage flame lamps	3,200
Eight 800-watt obscured high voltage flame lamps	6,400
Thirty-five 460-watt enclosed arcs	16,100

It is obvious that by doubling the height of all the lamps a floor space of four times the area would be illuminated to one-fourth the brilliancy, the relative illumination over the larger floor space being similar to that represented by curves A_1, B_1 and C_1, Fig. 6.



...Carbone 10 amp. 90 volt Lamp with Partially Obscured Globe.
O...... " " " " " " " Totally Opaque Globe.
O.... 6 amp. 70 volt Enclosed Arcs with Opalescent Inner and Clear Outer Globes.

FIG. 5.

Alternating-current Arcs. — Alternating-current lamps are very unpopular in this country on account of their very low useful efficiency. This is in a great measure due to the fact that about 50 per cent. of the light is thrown up into the air, where for many purposes it is entirely wasted. This defect, however, disappears in long-flame downward-feeding carbon arcs, as the whole of the light emitted by both craters is thrown down. Dr. Wedding has found that the efficiency of an alternating-current lamp of this type is practically similar to that of a direct-current arc of the same type.

The author has obtained a photograph showing the area of craters of a 10 ampere pure carbon high-voltage arc, the current being 10 amperes, voltage 67 and the area of the craters 15.3 sq. mm. The watts per square millimeter of crater area are therefore 44. They are consequently no greater for this alternating-current arc than for the 10-ampere direct-current arc.

Another objection to alternating-current arcs is that, when connected across an alternating-current circuit of less than 50 cycles per second, the flickering is very objectionable. It appears that this difficulty

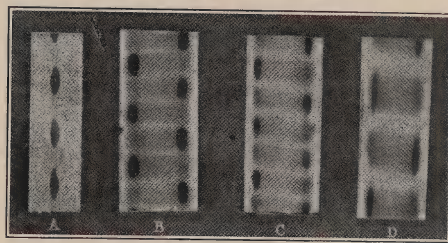


FIG. 6.

may also be considerably lessened by using downward-feeding carbon arcs in which both craters are visible directly below the arc. As in the ordinary coaxially arranged carbon arc only one crater is visible from any position during one entire half of each cycle, there must of necessity be a dark period between each flash of light.

OBSERVATIONS ON THE MERCURY ARC AND SOME RESULTANT PROBLEMS IN PHOTOMETRY

By C. Orme Bastian.

READ BEFORE THE GLASGOW LOCAL SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERING, ON TUESDAY, MAY 8TH. (ABRIDGED.)

Throughout this paper a distinction is drawn between the mercury arc lamp, which is provided with mercury electrodes, and the mercury vapor lamp, which is provided with electrodes of some non-readily vaporisable material (such as iron or carbon) in an atmosphere of mere mercury vapor enclosed at a certain low specific density. In the latter type of lamp—more akin to a Geissler tube—the density of the mercury vapor within it must be the same when it is cold as when it is heated and in operation, whereas the vapor density within the mercury arc lamp varies as the temperature varies, owing to vaporisation or condensation of the mercury at the electrodes.

The author's serious attention was first directed to the mercury arc in the year 1902, whilst experimenting with a mercury switch in series with a 200 volt 100 c.p. carbon filament lamp. The mercury was enclosed within an exhausted glass tube about ¼ in. diameter, and it was observed

that, on tilting the tube to cause the mercury to divide into two separate bodies, the effect was not to break the circuit, but on the contrary a 3-in. arc was formed between the two separate bodies of mercury, and at the same time it did not appear that there was any marked diminution in the light yielded by the carbon filament lamp in series. This brilliant 3-in. mercury arc was, therefore, apparently consuming a comparatively neligible quantity of energy, and the experiment furnished a sufficiently conclusive object lesson to encourage further trials, and particularly so when it was noticed that by enclosing the carbon filament lamp and the mercury "switch" under the same globe, a very pure white light was obtained from the combined spectra. It seemed as though something were being obtained for nothing, since the new combination certainly yielded much more illumination than the carbon filament lamp alone, and the consumption of energy was measurably less.

Extended trials have forced the author to the conclusion that there is an altogether unexpected gain in luminosity obtainable by combining the characteristic green light of the mercury arc with the light yielded by a carbon filament lamp, in which, of course, red is the predominating color; and it is thought that an explanation of this phenomenon may be found in a study of the physiological effect of light energy upon the optic nerve.

Every color produces a certain degree of visual effect, and white light undoubtedly produces the greatest visual effect of all. It seems not unreasonable, therefore, to conclude that an actual gain is effected by combining two colors to produce white light, and this being so, then the addition of a carbon filament lamp to a mercury arc lamp results in a much more efficient light-producing combination than one would at first expect. It would be idle to claim any degree of gain in visual effect if, by the blending of red and green light, there were merely produced a *mixed* effect due to those colors, instead of the entirely different *compound* effect which actually is the result of their combination. The increased illumination can be optically demonstrated by causing two beams of light, red and green respectively, to impinge side by side upon a white surface, and, after taking note of the illumination yielded by the two separate colored patches, deflecting the beams so that they are superposed, when a white light of greatly increased brilliancy will be the result.

It has been found impossible to first photometer a red light and then a green light, and then the white light resulting from the combination of the two, because the candle-power of a green light cannot possibly be determined or expressed any more than the intensity of one odor can be expressed in terms of a totally different odor.

The light from a candle bears no more relationship to the light from a mercury lamp than the smell of a violet bears to the smell of a rose, and any numerical comparison between them would be equally meaningless and impossible.

Several testing authorities have expressed the opinion that the impossibility of obtaining accurate and uniform results of the candle-power of a mercury lamp as compared with the usual carbon filament standard is to be ascribed to the Purkinje phenomenon, his law, according to Helmholtz, being as follows: "Intensity of sensation is a function of the luminous intensity, which differs with the kind of light;" and the author would amplify this law by stating that the optic nerves are proportionately more responsive to a white light than to any of the individual component colors, and that they respond to the component colors in varying degree. While the above law helps to explain the fact that a white light yields more visual effect than when it is resolved into its component colors, nevertheless it does not help towards an understanding of the further fact that a greenish-blue light gives better and better comparative photometric results as its distance from the carbon filament standard is gradually increased.

A mercury lamp tested at the Laboratoire Central d'Electricité (Paris) at 1.86 metres from the standard was returned as being of 14 c.p., but when tested against the same standard at the increased distance of 21.5 metres it was returned as being of 25 c.p., and the only explanation that was offered to account for the discrepancy was that it was due to the Purkinje phenomenon; but the author considers that this is no sufficient explanation at all, and that the varying results obtained are principally due to two additional causes: (1) The difference in the intrinsic light density of the two illuminants. (2) The different resistance offered by the atmosphere to the passage of different luminous wave lengths.

It must be remembered that the law of inverse squares is a law founded on purely geometrical considerations, based on the fact that light rays diverge in a definite manner, and on the assumption that the source of light is a point. In practice the latter assumption can, of course, never be correct, and the more diffused the light is at its source the greater will be the error due to this wrong assumption; and that this error is not of a negligible quantity will readily be appreciated when it is pointed out that the intrinsic light density of a carbon arc lamp, as compared with a mercury arc lamp, is in about the ratio of 40,000 to 10 as nearly as can be computed. Ganot points out that "it is important to observe that it is in consequence of the divergence of the luminous rays that light decreases as distance increases. This decrease does not obtain in the case of parallel rays; their

lustre would be the same at all distances were it not for the absorption, which takes place even in the most diaphanous media."

By absorption of light, transformation of light into non luminous wave-lengths must be understood, and it is submitted here that such transformation of light, due to the resistance of the atmosphere, is not taken any account of in practical photometry to-day, whereas proper consideration of the losses due to this cause would go far towards accounting for the discrepancies which are referred to above, and which, by most practical men, are regarded as unexplainable phenomena. It is difficult to conceive why these losses are not generally appreciated as probable sources of grave error in photometric work, and are not allowed for accordingly.

The further the photometric screen is from the source of light, the more nearly will the rays impinging on it be parallel to one another, and the lower the intrinsic light density at its source, the lower will be the light density of the approximately parallel rays in the intervening medium between the source of light and the screen; and, bearing this in mind, it will be apparent that, in the case of a carbon arc lamp, the light density in this intervening medium is about 4,000 times greater than it would be in the case of a mercury arc lamp; and it is submitted that the transformation of light into obscure energy in that medium would take place in the same proportion; and if so, this would sufficiently account for the fact that illuminants of low-light density, such as mercury arc lamps, incandescent gas mantles, bat-wing gas burners, etc., yield light of much greater penetrative quality than that yielded by an open-type carbon arc.

That the atmosphere conducts or transmits light of one color better than light of another color is no new theory, but a thoroughly established fact pointed out by Tyndall and others; and it is because air is a better conductor of blue light than any other color that distant objects appear blue, the light reflected from distant objects being all transformed into obscure wavelengths except the blue light, which persists as such with less proportion of loss.

Tyndall also states that transparent bodies assume the color which they best transmit; hence the blue color of the sky and the green color of water; and it follows that the atmosphere, composed as it is of air and water vapor, should be a better conductor of blue and green light than of any other colors; and this theory is exactly borne out by all photometric tests which have been made with the mercury arc lamp, in the spectrum of which, as is well known, in addition to yellow, green and blue, are very abundant. The mercury arc light compares more and more favorably with a reddish-yellow standard as its distance from the standard is increased, and it is maintained that this increase of distance, resulting as it does in an increased length of resisting medium—especially when considered in conjunction with the intrinsic light density at the two lamps—will better explain the non-uniformity of the results obtained than a consideration of Purkinje's law alone.

NOTES ON THE LIGHTING OF CHURCHES

By Edwin R. Weeks.

PRESENTED AT THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, NEW YORK.

Few inventions have been more far reaching, or more generally adopted, than those pertaining to artificial illumination. Places of amusement, public buildings, parks and boulevards, expositions, steamship lines, railroads, and residences—all vie with each other in the extent and decorative features of their lighting. Science has long since formulated the principles upon which improved methods are based and inventors and factories have supplied the apparatus; yet in one class of buildings there has been little, if any, effort to make full use of the possibilities of artistic and effective illumination. Churches are still characterized by the notoriously poor lighting inherited from the dark ages when the printed word was unknown.

Next to the acoustics, there is no feature of church architecture of greater importance than that of lighting. While defective acoustics are an annoyance at all services and deprive parishioners of much of the benefit and enjoyment for which they attend church, they do not belittle the architecture or deplete the exchequer. An inadequate system of lighting, however, is not only an extravagance, but it practically eliminates the beauty and effectiveness of capital, entablature, and vaulted roof with their costly decorations and symbolism.

The proverbial "dim religious light" of ecclesiastical structures is due to several causes. Architectural limitations produce an unequal, and at times, insufficient distribution even of daylight, and the immense distances through vaulted dome and transept make uniform artificial lighting by the old methods of suspension practically impossible. Again, the immemorial custom of using somber woods and gloomy wall-tints adds to the difficulties; and the inertia of precedent and a false economy continue these obsolete practices long after more scientific methods are available.

Suspension devices have persisted from the time of the torch and tallow dip, although the advent of a most flexible medium has made their use inexcusable. Chandeliers are, at best, costly in installation, wasteful, and hazardous in operation; grouping the lights at a few points, usually in the plane of vision, they are painfully

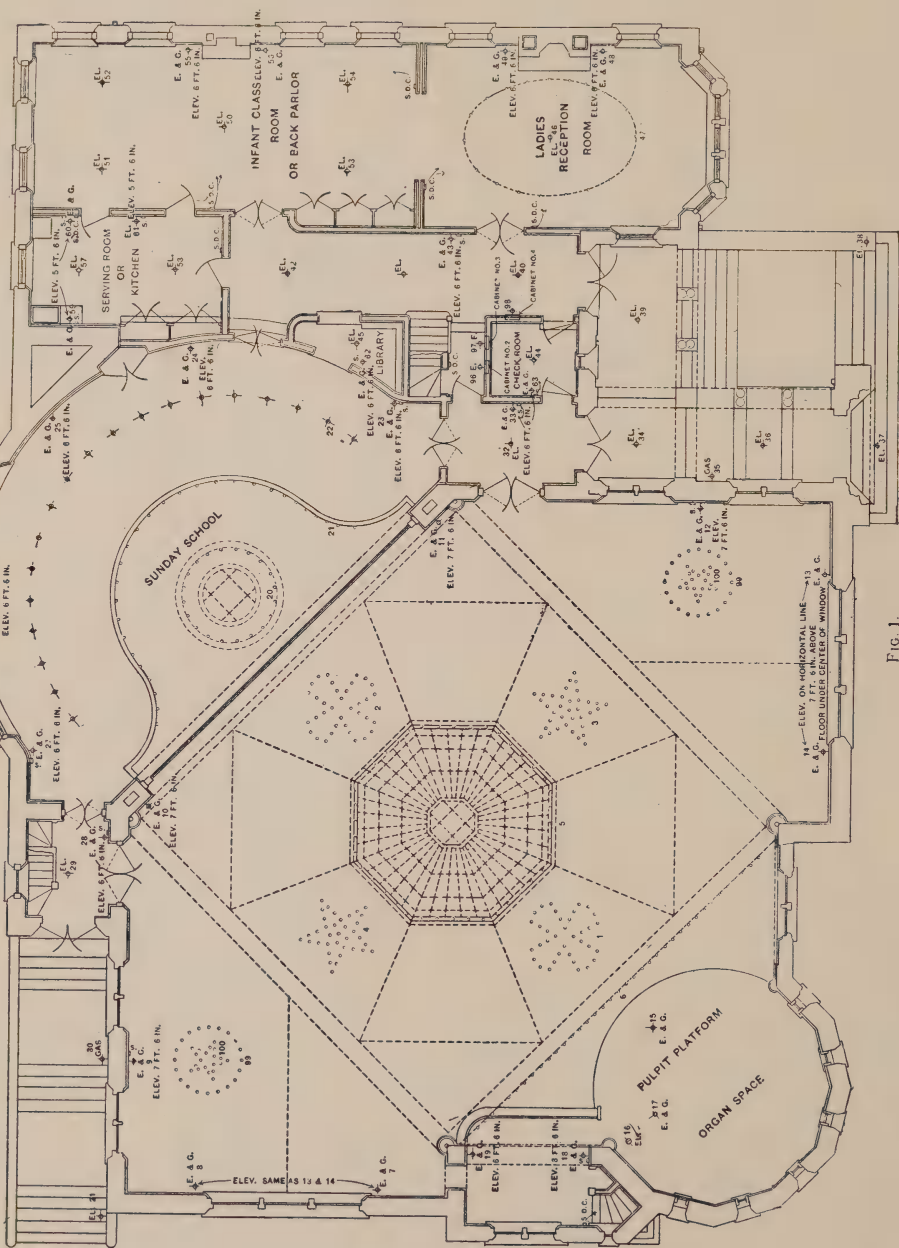

INFANT CLASS ROOM OR BACK PARLOR
LADIES RECEPTION ROOM
SERVING ROOM OR KITCHEN
LIBRARY
CHECK ROOM
SUNDAY SCHOOL
PULPIT PLATFORM
ORGAN SPACE

Fig. 1.

obtrusive and inartistic. In churches upon which large amounts have been expended to create spacious and inspiring auditoriums, it is not uncommon for the chief impression to be that of glittering pyramids, completely nullifying the sense of restful worship which should characterize such an interior.

It is, of course, true that lamps in receptacles flush with the ceiling or high wall-panels give less light in the reading plane than do the same lamps suspended a few feet above this plane; but when so placed they may be made to serve the purposes of uniform distribution, of didactic symbolism, and of displaying and even forming an important part of the architectural and mural decoration. These advantages furnish ample consideration for the cost of the additional lamps required to give the light needed in the reading plane.

The chief requisites in church lighting are adequacy and uniformity. The maximum variation throughout the auditorium should not exceed 20 per cent. This uniformity is seldom secured with daylight, but there is no reason why it should not be attained with artificial light, since electricity can easily be transmitted to all parts of the building and practically moulded to suit the demands of distribution as well as the needs of the architecture and decoration. In this respect the electric light may be said to "beat daylight."

The amount of light in the reading plane should not be less than two candle-feet; that is, about twice the light required by the average person for reading without the impairment of eyesight. The frugal vestryman may ask, "Why double the amount of light?" The answer is that the best and most attractive lighting is not only an excellent advertisement and a means of grace, but it may be quite economically employed in assembly rooms which are occupied but six or eight hours each month, if the controlling devices be properly designed and used. Furthermore, a religious gathering, more than any other concourse of people, contains persons of all ages, many of whom have failing eyesight, and all of whom should have sufficient light to enable them to read the lines of text or hymn. With an expense of two dollars an hour for light which gives perfect satisfaction to every one in the audience, and makes of the auditorium a beautiful and attractive place for young people, there can be no question of extravagance. The extravagance lies rather in employing a system which although it may cost half as much, fails to give satisfaction to any considerable number of the congregation.

A well-planned layout of switch-control effects a great economy in any installation; this is especially true in a building containing an assembly room and using a large number of lights. Where circuits are distributively interlaced, and a part of all the lamps are easily turned on or off, only those wanted at any time and place need be used, and none will be left burning because to light them later would be too much trouble. The most economic as well as the most convenient design so places switches that at least a part of the lamps in a room may be turned on and off at every door of the room. It is thus unnecessary, as with one switch, to walk back in order to turn off the light, and there is less danger of its being left on in unoccupied apartments. In rooms where varying degrees of light are needed, and service is for fixed and regular periods, the designer can so arrange the groups of lamps that there may be rotation of use, thus keeping them in uniform wear and preventing contrast when all are burning. These are a few of the devices with which the expert engineer so equips his plans that, although the cost of installation may seem large, it is more than offset by satisfactory service and economic operation.

There are two general systems of interior lighting, the indirect and the direct. In the indirect system, the lamps are entirely concealed from view and their light is distributed by means of reflecting or diffusing surfaces. The installation of this system is costly, uniform distribution is difficult, and, as only about 50 per cent. of the incident light is utilized, the system is wasteful. In the direct system, the lamps are so placed that, although they may be seen, they are not in the usual line of vision. The installation by this method is less costly, and its operation much less wasteful, since nearly all of the light emitted does useful work. It also facilitates uniform distribution, and lends itself more readily to decorative effects and the expression of symbolism.

The accompanying figures may serve to illustrate the application of these principles to a case wherein the expenditure is to be moderate. The results are a good distribution of light and a satisfactory illumination in each room. All parts of the auditorium are visible; each seat receives a minimum of two candle-feet, and the variation is less than 20 per cent. No more conclusive justification for the degree of control and lighting here provided for could be desired than the enthusiastic commendation of the parishioners, and the fact that the monthly bills for current at the rate of ten cents per kilowatt-hour, with the usual church services, and including current for organ motor, range from $15.00 to $23.20 dollars.

All lamps in any figure and in all figures in the same room are of uniform kind and candle-power. All lamps in auditorium ceiling outlets are clear standard Edison and all lamps in brackets are frosted spherical.

Review of the Technical Press

AMERICAN ITEMS

Electric Lighting at Summer Resorts on the Atlantic Coast.—*Electrical World*, June 2, 1906.

An illustrated article descriptive of the illumination at various resorts on the Jersey coast from Atlantic City to Jersey City. The illustrations, which are numerous, are mostly from photographs taken at night showing the illuminating effects.

Some Points in Illumination. By Cole Tay.—*Electrical World*, June 2, 1906.

The writer sets forth general rules to be followed in lighting of various kinds, giving explanations for same, and also explains the mathematical formulæ used in making the various computations of illumination, illustrating the results by curves and diagrams.

As to the intensity required he says: "The intensity necessary for good illumination varies from ½ foot-candle for general lighting of public halls, etc., ¾ for stores displaying goods in detail, 1 to 1½ for the illumination of ball rooms, etc., and 2 to 2½ for reading and desk lamps."

It is very doubtful if the layman would agree with him in considering the illumination represented by these figures as adequate. In a particular case of store lighting described in another part of this issue an illumination running as high as 11 foot-candles was not considered at all excessive by the managers and clerks.

Again he says: "Having chosen the intensity, the height of the lamp is determined by dividing the candle-power of the lamp by the foot-candles required, and taking the square root of the result; this gives us the height above the surfaces to be lighted."

He then proceeds to derive several mathematical formulæ for the placing of lamps based on this assumption, at the close of which he very properly discredits both the general rule and the formulæ by the following statement: "This is assuming that the lamps have a uniform intensity at the angles covered. This is not true of any particular kind of lamp or in different makes of the same kind of lamp."

Why, then, waste any time in deriving formulæ from conditions which never exist in practice? He further states: "The rated candle-power of any lamp is the spherical or hemispherical candle-power, the first being an average of about thirty-eight readings of the photometer taken at different angles through a complete circle; the second, the same readings taken through a semi-circle." These statements involve an error which it is particularly important to avoid. It is really remarkable to what an extent either absolutely erroneous ideas or imperfect conceptions on this point are prevalent. In the first place, there is no lamp, so far as we know, commercially rated at the present time upon its spherical or hemispherical candle-power. When candle-power is taken as a basis of rating, it is on the mean horizontal intensity. In the second place, spherical or hemispherical candle-power is not the mean of the intensities taken at various angles, but a quantity derived from these figures by either a mathematical or graphic process. In his calculations further on he does not distinguish between illumination on a horizontal plane and illumination on such a plane normal to the rays. His formulæ apply only to the latter case; that is, the method which he shows of determining the horizontal illumination gives the illumination normal to the rays at every point of the plane, and not the actual illumination upon a physical horizontal plane.

The Lighting of Public Halls and Lodge Rooms. By J. R. Cravath and V. R. Lansingh.—*Electrical World*, June 2, 1906.

A short illustrated article dealing with the particular cases of illumination mentioned. Their general directions are as follows:

"In the lighting of public halls, lodge rooms, and the like, the object to be attained is an even, general illumination of the whole room, with as little eye-trying glare in the eyes of the audience as possible. In lodge rooms of all kinds it is desirable either to conceal the sources of light, or, if this is not practicable, to place them high and so far out of the ordinary line of vision that the effect on the eye will be least detrimental."

Arc Lighting—Past and Present. By H. C. Rice. *Central Station*, June, 1906.

A brief and interesting historical review of the development of the arc lamp, from Sir Humphrey Davey to the present time. Illustrated with several cuts and diagrams.

Electricity as an Amusement Purveyor: Its Use for Fountain and Carnival Illumination. By Day Allen Willey.—*Electrical Age*, June, 1906.

An article describing and illustrating a number of electric fountains and other spectacular illuminating installations.

FOREIGN ITEMS

ON THE MEASUREMENT OF ILLUMINATION

The Electrician (London), May 18, 1906.

Herr F. Uppenborn describes in a recent issue of the *Elektrotechnische Zeitschrift* a series of tests which were carried out by the Munich electricity works to determine the distribution of light in a school room illuminated by two arc lamps. Before going into the tests the author referred to various instruments for measuring illumination. In Fig. 1, which represents one such instrument, the light penetrates through the frosted glass plate *p*, and is reflected by the mirror S on to the photometric screen P, behind which is a standard lamp NL. The photometer is calibrated empirically by illuminating the plate *p* by a lamp of given candle-power at a certain distance.

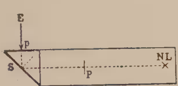


FIG. 1.

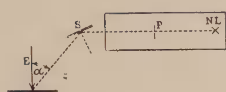


FIG. 2.

Another arrangement is shown in Fig. 2, in which *p* is a plate of cardboard, plaster of Paris, etc., of as white a color as possible. The light, which comes from the direction E, is here diffused, part of the diffused light being reflected by the mirror S on to P. The plate must be of sufficient size to prevent all light from the neighborhood of the plate from falling on S. Although the distance between the plate and S may have any value, it is advisable for practical reasons, not to adopt a larger distance than about 1 ft. 8 in. It is also well not to make the angle *a* too large, as reflection effects may otherwise occur.

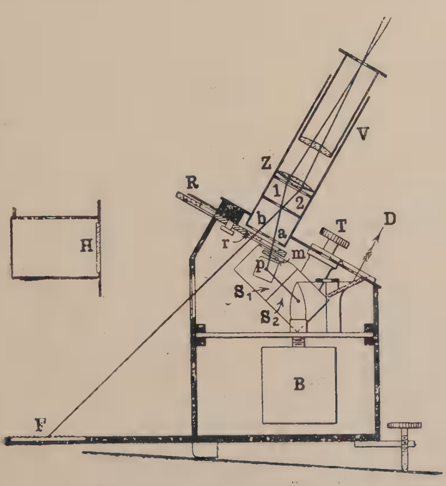


FIG. 3.—MARTENS ILLUMINATION PHOTOMETER.

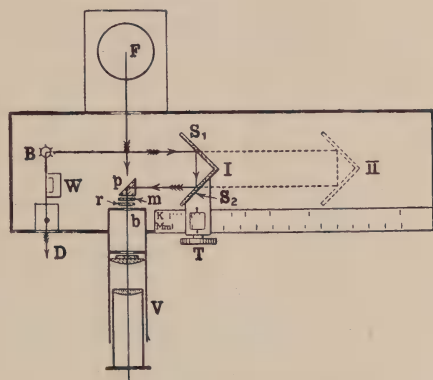


FIG. 4.—MARTENS ILLUMINATION PHOTOMETER.

Figs. 3 and 4 represent the Martens photometer, which is stated to be especially handy for carrying out illumination measurements. F is a plate of plaster of Paris, and is placed where the illumination is to be measured. B is a benzine lamp, whose light is reflected by the mirrors s_1 s_2 and the small reflecting prism *p* on to the frosted-glass plate *m*, from which the rays fall through the aperture *a* on to the part marked 1 of the double prism Z. Rays from F are directed by the aperture *b* on to part 2 of the double prism, and the illumination of parts 1 and 2 is rendered equal by regulating the illumination at *m*. This is done by suitably shifting the system of mirrors s_1 s_2. R is a disc of a number of smoked glasses *r* and serves to increase the range of measurement.

Fig. 5 is a plan of the school room, whose height is 13.1 ft. During the measurements, the three windows shown were covered with blinds of a light color. The position of the two arc lamps, which illuminated the room indirectly, are shown by the two large circles, the distance of the arc from the ceiling being 3 ft. 2½ in. in all cases. The figures at the positions indicated by full-black points were obtained by direct measurement, while the figures at the positions marked by small circles were obtained by interpolation. Of the two pairs of lamps experimented with, one pair consisted of differential arc lamps of the

	Polyphos lamps.	Siemens-Schuckert lamps of the Krizik type.
Mean illumination in lux	50.7	62.2
Mean current in amperes	10.69	10.64
Maximum current fluctuations	+2.62% and —2.44%	+0.85% and —0.96%
Average supply voltage	113.4	113.1
Maximum voltage fluctuations	+0.97% and —0.53%	+0.79% and —0.97%
Average voltage at the lamp	39.7	44.1
Maximum fluctuations	+1.76% and —1.26%	+0.45% and —0.68%
Watts per lux and square meter of floor	0.332	0.269

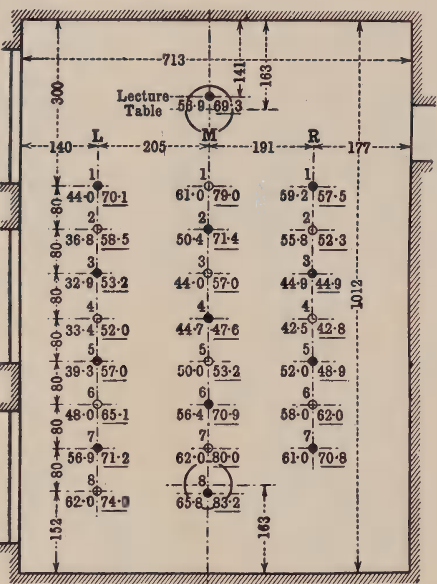


FIG. 5.—PLAN OF SCHOOL ROOM.

Krizik type supplied by the Siemens-Schuckert Company, while the other pair consisted of shunt arc lamps by the Polyphos Company. All lamps were provided with enameled reflectors of the open pattern. The underlined figures give the illumination in lux* for the Krizik lamps, and the figures not underlined refer to the Polyphos lamps. It will be gathered from the table below, in which further experimental data are tabulated, that the shunt arc lamps were not as good as the lamps of the differential type. This is due to the fact that the arc in the shunt lamps had to be adjusted to a smaller length. In consequence, a comparatively large portion of the light was screened by the negative carbon. It is also stated that the shunt arc lamps did not burn as steadily as the differentially-controlled lamps.

* A lux is the illumination produced on a surface at a uniform distance of 1 metre from a source of luminous intensity of 1 unit.

† From the *Electrical World* of New York.

A NEW IMPREGNATING FLUID FOR MANTLES

Journal of Gas Lighting (London), May 15, 1906.

The only successful and popularly approved incandescent gas mantle has been that made with an impregnating fluid composed of thorium and 1 per cent. or so of cerium. The frailty of the mantle was at one time held up as its greatest reproach; but it has, by its indisputable value as an economical illuminating agent, outlived censure in that one respect. It is now recognized that a well-made mantle, frail though it appears, will in use stand a fair amount of vibration, as is proved in street lighting and industrial establishments. To our mind, a matter for greater concern (though any mantle showing increased durability would be acceptable) is the fact that over the past twenty years, the incandescent mantle has been solely dependent upon the thorium-cerium impregnating fluid. Inventors have tried time after time to get away from it; but without any sufficient success to bring their alternative methods into prominence. And the result of the reliance on, and the indispensability of, thorium has been to make it the object of something akin to a "corner," and of the machinations of market operators. The price was doubled; and it has been—it is said only temporarily—decreased to about its former figure. How soon there will again be an upward move will depend upon the period that it takes to effect the purpose of those who so largely control.

This kind of thing is not calculated to give confidence; and therefore if an impregnating material can be found that will serve as a competitor with thorium, or will displace it if cheaper, then all associated with the gas industry will be most thankful. Mr. H. T. Grainger, of No. 16-17, Devonshire Square, E. C., states that he has discovered such a material for impregnating mantles, and its cost is so insignificant that mantles made by it ought easily to be retailed, with profit, at about 2s. per dozen.

As to the new impregnating material. No mantles made by it are yet obtainable; but Mr. Grainger informs us that some are now being produced. Again we are faced by the information that this is to remain

"a secret process." At the moment, the most interesting part of the information is that the chemical from which the impregnating fluid is made only costs about 2d. per lb., compared with 50s. per kilo. for thorium. This is of the highest importance if the chemical (whatever it is) is indestructible by heat. Mr. Grainger asserts that it is; but until mantles are available which can be put to proper test, definite statements on this head must be withheld. The inventor himself admits that the mantle has not yet been thoroughly tested in respect of wear and tear; but he believes it is going to be almost an "everlasting" mantle. If this is true, it will create quite a revolution in lighting. As to the illuminating power, it is said that the light which will be yielded by it will be far greater than that of the former mantle. All that can be said at present in this respect is that a number of pieces of material such as wool, cotton, cotton waste, and twigs that had been steeped in the new fluid gave, on being held in a flame, brilliant incandescent points. Beyond these statements we cannot go until completed mantles are at disposal; but sufficient has been said to arouse interest in the matter. If fortunately Mr. Grainger has discovered such a cheap impregnating material which in a bunsen flame will be as indestructible as thorium and cerium, then he will have conferred a no mean benefit on not only the gas industry, but mankind generally. We shall see.

A NEW FLICKER PHOTOMETER

Journal of Gas Lighting (London), June 5.

Some time ago, in the *Zeitschrift für Instrumentenkunde*, Herr Walter Bechstein, of Berlin, described a new form of flicker photometer, of which he gave the following particulars:

The instrument is so constructed that the one field of vision is alternately illuminated equally all over its surface and for an equal period of time, by both the lights that have to be compared. It is reversible, so that the standard light can be placed at either end of the bar, and inequalities in the two diffusive reflecting surfaces be thus eliminated. It can be used for the measurement of light issuing at any angle from the radiants. It is cheap, and is not subject to vibration, as none of the moving parts oscilates, and therefore it can be employed on a lightly-built bar.

The general construction of the optical arrangements is shown in section in fig. 1. The prismatic lens K is carried at a distance equal to its focal length from the diffusive reflector G, made of gypsum; and the plano-convex lens L is at a distance equal to its focal length from the observing aperture A. B is a fixed stop, limiting the field of vision. The aperture A may be either circular or slit-shaped; in the latter case, as K is rotated, its image travels over

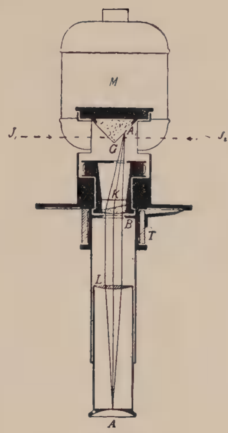


Fig. 1.

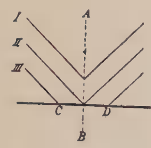


Fig. 4.

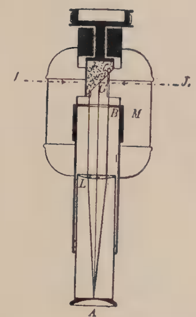


Fig. 5.

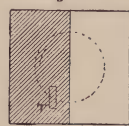


Fig. 2.

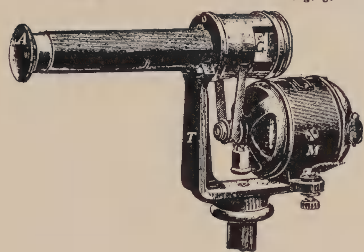


FIG. 3.

the reflector in the manner represented in fig. 2. The reflector can be rotated upon its axis; stops being provided which limit its motion to an angle of 180°. This movement allows either of its surfaces to be brought opposite the standard light, and also forms a means of adjusting the instrument accurately. If K is revolved to such a position that the image of the point of the reflector appears in the aperture A (especially when the latter is viewed through an eye-piece), a rotation of G itself should leave its image unmoved. When G is properly set, the whole field of vision is illuminated with light from the source J_1 on the left side, and with light from the source J_2 on the right side, for every half-revolution of the lens K. When the photometer is required for the measurement of light proceeding in directions other than the normal from the radiants, the entire instrument is made to turn within the sleeve T of its support.

The external appearance of the optical arrangements is shown in fig. 3 (without the fitting last mentioned), where M is a small direct-current motor of about 1-60th

	Both White.			One Green. One White.			One Red. One Blue.		
	A	B	C	A	B	C	A	B	C
Maximum	704	704	704	480	487	485	637	631	628
Minimum	697	696	695	472	478	478	626	610	617
Mean	699.6	700.1	698.6	475.4	482.6	482.0	632.2	619.2	623.0
Mean error per cent	0.94	0.77	1.09	1.15	1.13	0.76	1.5	3	1.4

horse power for 110 or 6 volts. If required, an alternating current motor can be employed instead; but the author finds that an electrically-driven motor is better for photometric purposes than a train of clockwork, which costs nearly as much. The speed at which K is made to revolve must be adjusted to suit each individual observer and the degree of difference in color between the two lights under test; but when the most favorable velocity has been ascertained, it should be kept constant. This is very easily managed with an electrical drive. Accuracy in comparison is the greater the smaller the area of the field of vision over which flickering ceases, but is almost impossible if it does not cease anywhere, as is the case when the speed of revolution is too low. The effects of different speeds of revolution are shown diagrammatically in fig. 4, where the dotted line A B is the optical center of the photometer, the ordinates the intensities of the flickering, and the abscissæ the positions of the bar. Curve I represents too low a speed. Curve II is the best, and Curve III too high a speed of revolution. When the speed reaches III, no flickering is to be detected over the whole area C D, and the proper position can only be judged by interpolation.

In order to show the concordant results obtainable with this form of flicker photometer when employed in the comparison of lights of different tints. Herr Bechstein gives a table of the single readings made by three different observers, two of whom were previously unacquainted with the flicker system. The lights under test were a pair of paraffin lamps of equal size and burning steadily. They were carried on the photometer at a constant distance apart of 1400 millimetres. In the first set of readings, both lamps were permitted to evolve their ordinary white light; in the second, the rays from one were passed through a distinctly green glass; and in the third, one set of rays were tinted ruby red and the other pale blue. The results may be summarized in the following manner; the figures being the distances in millimetres between the optical center of the instrument and one of the lamps. The three observers are designated by the letters A, B, and C, B being the only man possessing previous experience, and A being evidently a person regularly over-estimating the intensity of red illumination.

A very simple arrangement of the flicker photometer is shown in fig. 5; G being a right-angled prism of gypsum rotated upon the optical axis of the instrument by the motor M. Inequality of reflection is impossible in this type, because the same face of the prism is alternately presented to the two radiants; but the apparatus is less suitable for the measurement of light coming at abnormal angles from the sources. Inequality in reflection can be avoided in the instrument shown in fig. 1 if the reflector G is replaced by a cone which participates in the revolution; or, more simply, if the revolving portion carries a small disc of gypsum at the point A_1, which during rotation forms parts of the reflecting cone.

A NEW STANDARD PHOTOMETRIC OIL LAMP

By Arthur H. Elliott, Ph.D., Engineer-Chemist, Consolidated Gas Company of New York.

Journal of Gas Lighting (London), May 20.

When I wrote to the *Journal* several months ago [see Jan. 9, p. 97] about an oil-lamp used to serve as a guide to the gas engineer for the candle-power of the gas made in his works, I expressed the hope that the success of the lamp in my hands would lead to its adoption as a secondary unit for photometrical purposes. Since that time I have made many experiments, both alone and with the aid of others; and I venture to suggest the improved form of lamp as a secondary standard for photometric purposes, fully as constant as, and much more easily managed than, the pentane standard.

It appeared most desirable to have a flat surface of illumination, and not a cylindrical one, as that would be best suited to the more common forms of gas illumination. It has since been proved that the flat flame of the new form of standard lamp is much more easily adjusted and maintained, and is less sensitive to air currents, than a round flame source of light.

At the outset, I began to experiment with small oil-flames obtained from flat cotton wicks in common glass kerosene lamps. I found that these gave a candle-power ranging from 4 to 5 candles from a wick ½ inch wide to 15 candles from a wick 1½ inches wide. As I worked upon the question of maintaining the light at a constant value,

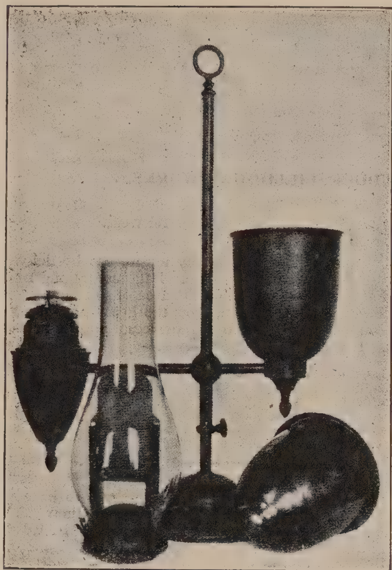


FIG. 1.—THE ELLIOTT IMPROVED FORM OF TEN-CANDLE OIL-LAMP.

I was agreeably surprised to find that, with even considerable change of oil-level in the reservoir, a fairly constant candle value was maintained by the flame. When I applied the constant feed of the student lamp to the flat-flame oil-burner, the light value became practically constant, and a lamp fitted with this arrangement and a wire gauge to determine the light of the flame at all times, gave me a very useful standard for works' use for some months. With a desire to improve the lamp, and to get the best results I could out of it, the form now to be described was gradually evolved.

I have had my attention called to a small pamphlet sent out by the General Electric Company, in which they say that a double-wick kerosene-oil lamp used as a standard of candle-power to test incandescent electric bulbs was very satisfactory. The statement is as follows: "The oil standard was adopted after extensive experiments to prove its reliability." But they do not say what these experiments were. I believe the results of the experiments given with this paper at the present time are the first that show any details.

At the outset the points that appeared important to determine were—

1.—Is this source of light constant over considerable periods of time?

2.—Is the lamp, as arranged, easily adjusted?

3.—Can two persons working with the same lamp produce with it practically a light of the same candle value?

4.—Can two or more lamps be made from the same specifications, and give the same candle values?

5.—Can wicks be obtained of uniform quality and structure and give practically the same candle value with the same oil?

6.—Will oils of slightly different densities and constitution give the same candle value?

7.—How long can a cotton wick of standard quality be used?

8.—How do the variations of light value of the lamp, as presented, compare with the variations of the light value of candles?

I hope that the experiments here presented are sufficiently complete to induce my fellow-workers in this line to consider the merits of the new standard as a simple and complete substitute for candles, and of far more constant value than these troublesome units.

In answer to the first question—constancy—the following experiments are pretty conclusive: Taking the same stock of oil, and with all conditions of wick and lamp as near the same as fairly careful operators can make them, the following figures were obtained. Each line contains the observations of 24 hours; the lamp burning continuously (one stop for slight trimming only, each day). The results are candle powers of lamp against standard candles duly corrected. (See Table I.)

Here are a set of observations under the same conditions, but with two other observers at another station, and a cotton wick about 20 per cent. lighter than the one used

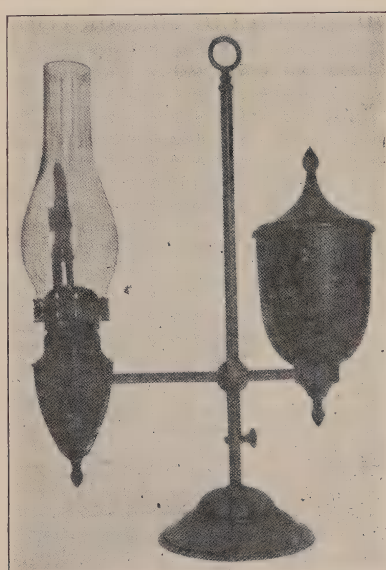


FIG. 2.—THE PARTS OF THE LAMP SEPARATED.

TABLE I.

First day	10.02	9.84	10.08	9.88	9.75	10.03	——
Second day	9.70	10.05	——	——	——	——	——
Third day	9.99	10.04	9.79	9.80	10.08	9.99	9.98
Fourth day	10.21	10.08	10.04	10.03	9.96	——	——

in the experiments given above. The candle-power is lower for the same screen opening, owing to lack of thickness in the wick. But note the constancy. Each pair of readings shows the night and day observations against candles made by the men used to taking candle-powers every hour:

(8.0 9.0) (9.0 9.1) (9.0 9.2) (9.1 9.1)

To still further prove the reliability of the flame value over many hours of burning, I placed a lamp at the disposal of Dr. Clayton H. Sharp, of the Electrical Testing Laboratories of New York, and Table II. gives the figures of his report.

All tests were made against an invariable electrical standard lamp. The figures go to show that the flame of the lamp is remarkably constant over long periods of time.

The second question is also answered from the above-mentioned figures. In the first series of tests, two persons managed the lamp. In the series at the Electrical Laboratories, three persons managed the lamp—one of them a lady. It is certainly most easily adjusted, and any two ordinarily careful persons adjusting the same lamp will get almost absolutely the same candle-power. Note the electrical tests.

In answer to the fourth question, it has been proved that it is very easy to make a number of lamps so much alike that when placed against each other at opposite ends of a photometric bar and observed by several persons, the greatest differences in value will not exceed two-tenths of a candle-power—of course, using the same oil and the same standard of cotton wick. Twelve lamps have been so tested.

In regard to wicks, it is perfectly easy to obtain, here in America, cotton wicks that are remarkably close to uniformity in size, weight, and weave. Having obtained a good wick, buy a gross of them and your work will run very uniform. Felt wicks are good; but the experience given here is all with cotton wicks of the size and standard mentioned later. With wicks from the same packages (gross), identical results are obtained.

With respect to the density of the oil used, it is best to employ an oil that can be readily obtained, of a uniform quality and density. Nevertheless, oils varying from 50° to 46° Beaumé appear to give the same results. Oils of 50°, 48°, and 46° Beaumé have all been tried with the same candle value at the flame opposite the opening in the screen of the lamp.

A cotton wick has been used for about ten days (with only the slight trimming off of the black crust, and also the angles at the sides to maintain the proper flame-width); and then it began to show signs of loss of capillarity and the flame could not be readily kept at constant height. It was also found to be very brown and dirty for some distance down, when it was removed from the wick-tube. It is fair to say that a cotton wick of the standard given will last about one week. Wicks are so cheap, it is foolish to economize in this direction.

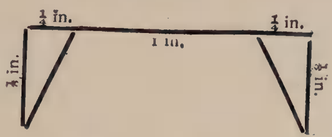
In regard to the constancy of the lamp, as against candles, the electrical standard has already been mentioned, showing that the lamp itself does not vary more than 3 per cent. in several days' usage, while the majority of the daily observations are close to 1 per cent. This is a record candles have never shown or approached.

The lamp in its improved form (fig. 1) is the result of many months of experiment, both in my hands and others who have very kindly assisted to bring forth a readily managed unit of light for photometric purposes. The body of the lamp consists of a large reservoir, holding enough oil for twelve hours' service, and supplied with the usual valve-feed of the student lamp—thus insuring a constant level of oil at all times (see fig. 2.). The consumption of oil is 40

TABLE II.

Day.	Time.	Candle-Power.	Air Temperature.
First	2.00 P.M.	10.20	72° Fahr.
	3.00 P.M.	10.19	72° "
	5.00 P.M.	10.32	72° "
Second	9.00 A.M.	10.33	69° "
	12.00 M.	10.37	
Third	9.00 A.M.	10.32	68° "
	1.30 P.M.	10.40	68° "
Fourth	10.00 A.M.	10.19	70° "
	1.00 P.M.	10.00	
	4.30 P.M.	.9.92	70° "
	8.00 P.M.	10.00	
Fifth	9.00 P.M.	10.40	72° "
	4.30 P.M.	10.40	

grammes per hour, and is remarkably regular, as the results have shown. The burner carries a flat cotton wick of "D" size, and is 1½ inches wide; although it is trimmed to use only 1 inch wide, the corners being cut off equally on each side of about the form of a right-angled triangle, thus—



This trimming is important, as it determines the best form of flame, and is the result of a large number of experiments. The flame thus produced is remarkably constant in height and illuminating value. It is very much less sensitive to draughts of air than any round-wick flame, and especially air-gas flames like the pentane standard.

A felt wick has been used, and works very well for about four days; but a cotton woven wick will last at least a week and perhaps much longer, according to the density and purity of the kerosene oil used. And no matter what oil is used, when once its value in the lamp is determined, it can be depended on to give a constant candle-power for the same screen opening—yet not necessarily 10 candle-power obtained with Pratt's "Astral" oil, with which the lamp was standardized and improved.

If the wick is not trimmed carefully, long tails will rise from the ends, and thus crack the chimney from local over-heating.

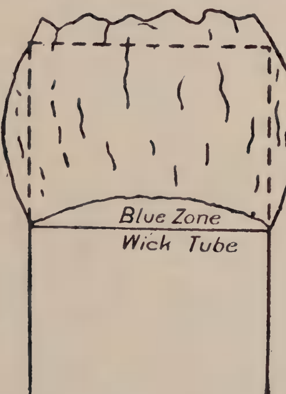


FIG. 3.—FORM OF FLAME.

It is best to trim the wick in its dry condition before putting it into the oil, and use a sheet brass pattern to give it the proper flame. After trimming as well as possible, and while the wick is still dry, singe it free from fluff and irregularities, so as to obtain a smooth, even curve around the upper edge. In this way a flame of the form shown in fig. 3, and which just covers the sides of the opening and upper corners of the screen opening, is obtained with ease. A little care at this point is well spent and insures days of comfort with the flame afterwards.

The chimney used—Macbeth's No. 40, pearl glass—has been found most satisfactory, lasting many months with ordinary care. This chimney is 10 inches high, 1¾ inches inside diameter at top, and 3 inches wide outside at bottom, where it fits the gallery. At the widest part it is 4 inches; but this is not important as to close measurement—¼ inch more or less having no effect.

The screen is attached to the cone-cap of the burner, through which the flame rises from the wick, by two uprights that carry a sheet-iron disc and two sheet-iron side wings. The upper disc is adjustable to allow for increasing or diminishing the opening when using different oils—see fig. 5. With Pratt's "Astral" oil, this screen opening is made ⅞ inch over the crown of the cap, and 1½ inches between the side wings; the flame thus exposed giving 10 candle-power. This has been tried with twelve lamps made up for use with the same measurements and directions. There is no reason why it cannot be repeated indefinitely with the same type and quality of oil and wick. The total height of the flame above the burner-cap is about 1¼ inches.

HYGIENIC ASPECTS OF INVERTED GASLIGHTS

Journal of Gas Lighting (London), May 8, 1906.

Recent issues of the *Journal für Gasbeleuchtung* contain a lengthy article, written by Dr. F. Ballner, a physician attached to the Austrian Army, upon the incandescent gaslight viewed from a hygienic aspect. The greater portion of his communication is taken up with a discussion of the amount of radiant heat produced per unit of light by different types of gas-burners; but there is a good deal of introductory matter that must be studied in order to gain a proper comprehension of the results at which the author has arrived.

The energy consumed in evolving light is made manifest in two different ways—part of it appearing as radiant energy and part as conducted heat. The latter is transferred to the structure of the burner and to the air in the vicinity. From a hygienic aspect, it is of less importance than the radiant energy. The radiant energy is composed of rays that cover the whole field between the wave-lengths 60 and 0.4 μ. The rays having wave-lengths lying between 0.8 and 0.4 affect the eye; the former being at the extreme red end of the visible spectrum, and the latter at the extreme violet end. The rays between 60 μ

and 0.8 μ are invisible or heat rays. In the course of the investigation he carried out some ten years ago, Rubner described the various symptoms experienced by a person unduly exposed to the radiations from a source of light. He found that a person whose face was exposed to the light of a 15 candle-power argand burner at a certain distance began to feel only an indefinite sensation of warmth, next a sensation of heat in the eyes and root of the nose, then a tension of the forehead, afterwards a burning of the eyes and a tendency to shed tears, and finally extreme dryness and heat in the eyes. He also found that the symptoms described were produced by a smaller quantity of radiant energy in a warm room heated to the temperature of 70° or 80° Fahr. than in a cool room when the thermometer did not rise above 57° Fahr.—in other words, that more than twice as much radiant heat can be borne in a cool room as in one that is overheated. Rubner also observed, as the result of experiments on numerous persons, that the ideal quantity of heat received from a source of light ought not to exceed 35 microcalories per square centimeter per minute, but that in practice 50 microcalories might be considered as the utmost permissible from a hygienic standpoint. [The microcalorie referred to in this abstract is defined by Ballner as the one-thousandth part of the small freezing-point calorie—*i. e.*, represents the amount of heat necessary to raise 1 milligramme of water from 0° to 1° C.] In his examination of actual sources of artificial light, Rubner observed great variations in the quantity of radiant heat emitted; his maxima and minima being 14.44 and 1.24 microcalories per square centimeter per minute, measured at a constant distance of 37.5 centimeters (14.8 inches) from the radiant. He discovered the petroleum lamp was the least advantageous source of light from the present aspect; the Welsbach light being the best, and the electric glow lamp the second.

THE BURNERS EXAMINED.

Dr. Ballner has taken up the subject of the amount of heat radiated from inverted burners on the ground that the great differences in their design from the typical upright incandescent must alter the ratio between quantity of radiant heat and illuminating power which Rubner and others have found to obtain in the case of ordinary Welsbach burners. In the inverted burner, a much larger proportion of the total heat evolved is communicated to the metal and glass portions of the burner, and to the gas and air before ignition occurs. For the purposes of comparison, he has also tested other varieties of gas-burners; the samples examined comprising a flat-flame burner, an argand, apparently three different specimens of the upright Welsbach (one of which had been in regular use for a considerable period of time), a small inverted incandescent made by Kramer, of Berlin, and a large inverted burner constructed by the Incandescent Gas Company of Vienna.

The burners were tested for consumption at a pressure of 15-10ths, for illuminating power and duty, on a Weber photometer. In the case of the inverted burners, lower hemispherical candle-power was determined every 15 degrees between the horizontal and the vertical; and the average was taken for comparison. In other tests, the inverted and the upright burners were compared in their most advantageous directions—viz., horizontally with the upright burners; at a depending angle of 45° with the inverted specimens.

The individual results given by these and the other burners are also collected in the following table (No. 1) after recalculation of the figures into British units. Where marked with an asterisk, the data relate to mean lower hemispherical candle-power; elsewhere they refer to the light and duty emitted in the most advantageous direction, as already stated.

From a physiological aspect, it is important that the light shall be perfectly steady and uniform. Want of steadiness in a light strains the iris and the accommodating muscles of the eye very severely. The Vienna inverted burner gave a perfectly steady light, but the specimen of the Kramer burner that was tested flickered somewhat and produced a crackling ("boiling") noise, however carefully the gas supply and the size of the air inlets were regulated.

TABLE I.

Type of Burner.	Consumption Cubic Feet per Hour.	Illuminating Power.	Candles per Cubic Foot.
Flat-flame	7.00	15.8	2.26
Argand	4.13	14.3	3.5
Welsbach (old)	4.67	46.7	10.0
Welsbach (new)	4.88	72.0	14.7
Welsbach (?)	3.96	53.0	(13.4)
Kramer inverted	2.14	31.6	14.8
Kramer inverted* ...	1.98	30.7	15.5
Vienna inverted	3.01	47.0	15.6
Vienna inverted*	3.00	46.5	15.5

MEASUREMENT OF THE RADIANT HEAT.

In measuring the heat radiated from the different burners, the method already employed by Rubner was followed closely. A D'Arsonval galvanometer was used, connected with a Melloni thermopile carried on a bar divided into centimeters.

With the aid of the apparatus thus arranged, the quantities of heat radiated horizontally per unit of light emitted by the different burners were measured; and the average of many results in each case are recorded in Table II. The upright Welsbach burner tested was the same specimen

as the third mentioned in Table I. The figures in the second vertical column of Table II. represent the number of microcalories received per minute upon a surface of 1 square centimeter at a constant distance of 37.5 centimeters from the source of light per 1 Hefner unit developed.

In similar conditions, Rubner found values ranging from 5.3 to 7.76 for a flat-flame burner, 7.2 for an argand, and an average of 1.25 for ordinary Welsbachs.

In Table III. are shown the amounts of heat radiated from the two inverted burners when alight, tested with and without the inner globe, and the corresponding quantities radiated from the hot portions of the burners themselves immediately after the flames were extinguished. It will be seen that the presence of the globe increases the illuminating power of the flame, presumably by checking losses of heat, but also by protecting the flame from draughts, and so enabling it to fill the mantle more thoroughly. The globe has also a small effect in reducing the amount of radiant heat given off.

Hence it appears that the greater part of the heat is radiated from the hot metal and glass portions of the burners themselves. The differences between the readings given by the extinguished burners with and without globes—viz., 211.6° and 94.9° respectively—indicate the amounts of heat radiated by the globes. The Kramer globe weighed 45 grammes; the Vienna globe, 31 grammes. This fraction of the radiant heat must diminish with the weight of the glass article emitting it; and therefore the inverted burner has an advantage over the upright burner, inasmuch as the chimney of the latter (the analogous glass object) weighs two or more times as much as the inverted globe. The amount of heat radiated from the electric light is roughly double that emitted by the upright Welsbach.

The heating effects of a source of artificial light may also be judged to a certain extent from the color of its flame; being the greater as the light contains a larger proportion of red rays. Hence if the illuminating power of the light is measured in terms of red (R) only and green (G) only, tinted glasses being employed on the photometer, the amount of radiant heat per unit of light is the smaller as the fraction $\frac{G}{R}$ is the greater. The ratio in question was measured for all the burners under examination, and was found to be 1.12 for the argand, 1.14 for the flat-flame burner, 2.2 for the upright Welsbach, and 2.3 for both the inverted burners—figures which will be seen to vary inversely with the microcalories recorded in Table II.

TABLE II.

Type of Burner.		Microcalories per Hefner Unit per Sq. Cm. per Minute at 37.5 cm. Distance.	Microcalories per Candle-Power per Sq. Ft. per Minute at 1 foot Distance.
Flat-flame		5.2	58.0
Argand		6.5	72.4
Welsbach		1.4	15.6
Kramer inverted	globe only	1.73	19.25
	with shade	1.469	16.35
Vienna inverted	globe only	1.864	20.72
	with shade	1.418	15.8

TABLE III.

Type of Burner.		Illuminating Power. Hefner Units.	Microcalories per Hefner Unit.
Kramer light	with globe	37	1.718
	without globe	31.9	2.139
Kramer burner	with globe	—	—
	without globe	—	—
Vienna light	with globe	56	1.508
	without globe	42	2.059
Vienna burner	with globe	—	—
	without globe	—	—

TABLE IV.

Type of Burner.	Total Heat per Hefner Unit per Hour. I. Gross.	II. Net.	Radiant Heat as a Percentage of the Total Heat. I. Gross.	II. Net.
Vienna	9.7	8.7	20.1	22.5
Kramer	9.78	8.84	18.8	20.8
Argand	40.11	36.28	17.3	19.2
Flat-flame	62.15	56.21	8.6	9.5

Available Illumination.—Another hygienically important point in considering the values of different lights is the intensity of the illumination they yield when brought so close to the person using them that he is exposed to the maximum permissible amount of radiant heat. This value, expressed in "meterkerzen" or the like at the minimum permissible distance, has been termed by Rubner the "available illumination."

The maximum available illumination afforded by the Kramer burner under "ideal" conditions is 11.44 candle-feet; and under "practical" conditions, 16.14 candle-feet.

Similar calculations applied to the Vienna inverted burner lead to a maximum "ideal" illumination of 11.4 candle-feet, and a maximum "practical" illumination of 16.4 candle-feet. The upright Welsbach burner, tested by Rubner himself, exhibited corresponding values of 13.4 and 22.3 candle-feet.

RATIO OF RADIANT HEAT TO TOTAL HEAT.

If the calorific value of the gas consumed in each of the burners per hour in the development of unit light is known, it becomes possible to calculate the proportion which the quantity of radiant heat emitted bears to the total heat produced by the combustion. The work was carried out with Innsbruck gas, which, as a mean of six determinations in the Junkers calorimeter, was found to possess a gross calorific value of 5,650 large calories per cubic meter (160 large calories per cubic foot), and a net value, after deduction of the latent heat of the steam produced, of 5,110 large calories per meter (144.6 per foot). Table IV. shows the total gross and net amount of heat evolved per hour in large calories per 1 Hefner of light, and the proportion to these totals of the quantity of radiant heat emitted under the same conditions. The figures can be converted into British units by multiplying by 1.14 (the correction for our larger "candle").

The total heat developed by an upright Welsbach burner examined by Rubner was 8.07 large calories net per hour per 1 Hefner. From a thermic standpoint, the electric glow lamp is a better source of light than incandescent gas. According to Rubner, its total evolution of heat is only one-sixth that of the incandescent gas-burner, although its radiation of heat is somewhat greater. Rubner quotes the radiation from a glow lamp as 2.63 microcalories per minute upon a surface of 1 square centimeter at a distance of 37.5 centimeters—*i. e.*, rather more than that of the gas-burners. After deducting the latent heat of the water-vapor, Rubner found that the radiant heat of Welsbach burners represented 17 per cent. of the total heat, whereas the radiant heat of a glow lamp is 71 per cent. of its total heat.

TESTING INCANDESCENT MANTLES

The rating of incandescent lamps as to candle-power, efficiency, and life, has been brought to a remarkable degree of exactness in this country, a result due largely to competition, which has caused manufacturers to bend every energy toward securing the highest possible degree of excellence in every detail. The Welsbach mantle may be considered the counterpart of the incandescent lamp in gas illumination; and while we have no figures at hand, the number of mantles sold must reach many millions a year; and yet there is absolutely no commercial rating of incandescent mantles in this country. Mantles can be bought at all prices from 10 to 50c., and as might be expected, of all varying qualities as well—the quality, however, not always varying directly with the price.

Why should there not be some method of rating gas mantles? Commenting on this subject, the (London) *Journal of Gas Lighting* says:

It is to be feared that there is a good deal of perfunctoriness in this matter; and that consumers are left too much without guidance. If the mantles on the market were the subject of the constant attention of gas engineers, followed by advice to the consumers, the vendors of mantles would soon see the wisdom of only stocking those classes that met with the approval of the gas authorities. It would not be a bad thing, too, where constant tests are being made of mantles at a gas-works, to go farther, and send round to shopkeepers dealing in mantles a list of the "brands" that the tests disclose are the most satisfactory. In such a case, in order that injustice should not be done, it would be necessary that tests of mantles should be made periodically. All makers of incandescent mantles are not rogues; but those who are not can produce evidence of many who are. And therefore a periodical testing would be requisite. Then, again, it would not be wise that the tests should be made only with mantles delivered direct to the gas offices; mantles purchased from the local retailers should also be brought to the works' test-burners. This precaution would be necessary because the mantle market has lent itself all too extensively to the machinations of tricksters, as certain of the leading makers have found to their cost. It is only by continued scrutiny that deception will eventually be brought to book, and indigent mantles cease to exist.

Miscellaneous News

ALBANY, N. Y.—The new contract for electric lighting which the city has entered into with the Municipal Gas Company goes into effect on June 21 and the city will save $16,615.20 a year by it. This saving will also enable the city to add some 50 or 60 new lights to the present service within a very short time. Distributed pro rata it would mean about three new lights for each ward.

AUBURN, N. Y.—The State Gas and Electricity Commission is investigating the affairs of the Auburn Gas Company. The Mayor claims that since the combination of the Citizens with the Auburn Gas Company gas has been piped from Geneva, where it is made as a by-product by the Empire Coke Company. He claimed that the company pays only 25c. per thousand and sells it in Auburn at $1.35. The cost of piping and distribution would bring the cost up to only 47.3c. per thousand.

BUFFALO, N. Y.—The local gas situation will be investigated by the State Commission. The Corporation Counsel has secured a copy of all of the evidence taken at the Syracuse investigation as a guide. The date of the hearing has not yet been decided.

LITTLE ROCK, ARK.—The City Council granted a franchise to John G. Vogel for an electric light, heat and power plant and embodied in the ordinance a contract for the lighting of the streets of the city by 60 electric lights, which the city agrees to pay for during the fifty years' life of the franchise at the rate of $600 per month.

LOS ANGELES, CAL.—The Board of Public Works contemplates cutting down the candle-power used in the ornamental lights on Main and Hill streets. It is reported that the Pacific Power and Lighting Company are devising a scheme whereby the expense will be as great as if the Board had not adopted the money-saving policy.

NIAGARA FALLS, N. Y.—A number of the merchants of the city have made a proposition to the Council for installing a better illumination on one of the principal streets. The proposition made is as follows:

That the city bear one-half the expense of illuminating Third street from the tracks of the New York Central Railroad Company to Niagara street with 535 incandescent lights; the cost to the city the first year to be about $300 and about half of that sum in subsequent years, the merchants bearing a like proportion of the expense.

The illumination is to consist, as stated above, of 535 lights to be ranged on either side of the thoroughfare at a distance of two feet apart, and on four arches to span the street, one at the Niagara street end, one near the railroad tracks and two at equal distances from the end arches in the length of the block. This will give one of the most brilliantly illuminated streets to be found in the country and would go a long way toward upholding the title of the Electric City.

It has been ascertained by the merchants that it would cost about $250 to string the wire and install the arches for the lights.

The actual cost of maintaining the illumination would be about $93 a month, the lights to be maintained from July 1 to October 1, or for such period as may be agreed upon.

Mr. Simmons asked that the Council assist the merchants in their commendable enterprise. He maintained that it would establish a precedent, and that in a very short time the spirit of progress would become contagious and that other business sections of the city would be illuminated as well.

It has been figured by the merchants that the cost, if the city pays half the expense of illuminating the street, will be about $1.10 a month for twenty feet frontage, or $2.20 if the city pays nothing. This is considered a very insignificant amount considering the benefits that would surely accrue to the business men of the street. It is pointed out that the scheme is practical, feasible and highly commendable; that it would be the beginning of a general illumination of the business districts of the city, and a mark of credit to the enterprises of Niagara Falls' merchants.

PHILADELPHIA, PA.—Despite the action of the Commonwealth Electric Company in withdrawing from Councils its ordinances to permit of competition in the electric lighting of city streets, dwellings and business establishments, rivalry for the contracts in 1908 or 1909 seems assured. The Commonwealth has only temporarily withdrawn its ordinance for redrafting in more explicit language. Its revised ordinance is now before the Mayor and his Advisory Board, which also has before it the rival ordinance of the Citizens' Electric Company.

POTSDAM, N. Y.—At a special village election to decide upon a proposal to bond the village for $24,000 for the construction of a municipal lighting plant to supply street lights only, the proposition won by a majority of 58. About one-third of the votes were cast by women, who favored the municipal ownership proposition.

ROCHESTER, N. Y. — Corporation Counsel Webb and his assistants have received instructions from Mayor Cutler to prepare the city's case in the inquiry into gas and electric conditions in Rochester

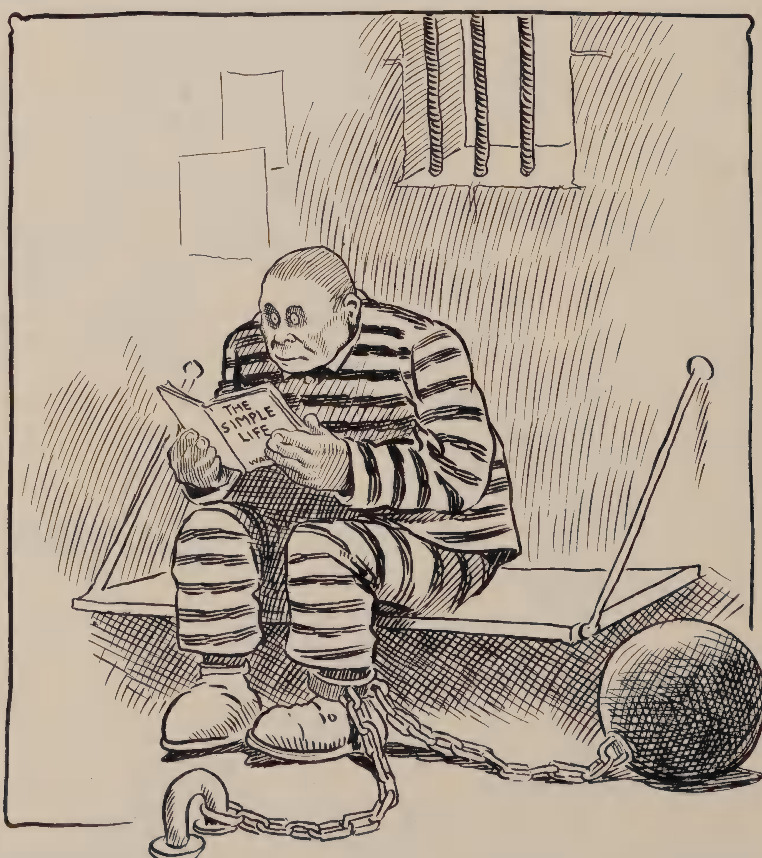
as quickly as possible for transmission to the State commission in gas and electricity. The work is to be done as soon as it can be done thoroughly. It is expected that it will take about a week to prepare the information now in the possession of the city authorities and such information as they may receive.

TROY, N. Y.—After a fight of several months the city authorities of Troy have reached an agreement with the Troy Gas Company. The Board of Contract has awarded a contract on the company's bid to furnish 468 arc lights of 2,000 candle-power at 26 cents per lamp. The old price was 32 cents. The saving to the city is about $17,000 a year.

When the old contract expired the company submitted a price which represented a saving of $10,000 a year, but the mayor took the ground that the figure was too high and a bill was introduced in the Legislature to give the city power to maintain its own lighting plant. This measure was defeated and the local authorities decided to present their grievance to the State Gas Commission. The reduced bid was then presented and accepted.

The company also announced that beginning June 1 the price of gas to consumers in general would be reduced five cents per 1,000 feet each year until the price is down to $1.10 per 1,000 feet. The price at present charged the public is $1.30 per thousand. The company also agrees to furnish the public with electric light at 15 cents per kilowatt per hour. The price charged at the present time is 16 cents per kilowatt.

WASHINGTON, D. C.—The census bureau has issued a preliminary summary of the statistics of manufactured gas for the United States for the calendar year 1904 as compared with 1900, the year of taking the twelfth census, according to which there were in operation in 1904, 1,017 establishments, an increase of 16 per cent. over 1900. The total value of gas manufactured was $125,036,055, an increase of 65 per cent. All other products, $13,272,434, an increase of 111 per cent.



ILLUMINATING ENGINEERING DATA ILLUSTRATED: A BALL-AND-CHAIN DESIGN FOR FIXTURES.

The Illuminating Engineer

Vol. I. JULY, 1906 No. 5

Practical Problems in Illuminating Engineering

By Arthur A. Ernst.

V.—A PECULIAR CASE OF INDIRECT ILLUMINATION.

Indirect illumination, that is, illumination by diffuse reflection from light-sources entirely hidden from view, is usually considered one of the most elegant and satisfactory methods, but seldom practical on account of the low efficiency obtained. With proper care in the selection of reflectors and the position of lamps, and in cases where there is a minimum of smoke and dust to be reckoned with, the method is far more efficient than is commonly supposed, and is especially available for cases where a moderate and uniform general illumination is desired. These conditions exist in offices, reading rooms, drafting rooms, hallways, and other similar locations where either special illumination is to be provided for uses requiring close attention, or where only general illumination is necessary.

The most common faults with installations of this kind are spots and streaks of light on the white surface of the wall or ceiling which serves as a reflector, thus plainly indicating the location of the lamps, and obvious differences of intensity on the portions farthest removed from the light-sources. From the artistic standpoint either of these faults is fatal. Unless the reflecting portion of the ceiling can be practically uniformly illuminated, and the light-sources not only kept out of sight but their locations concealed as well, the scheme "gives itself away," so to speak.

In the present example the structural conditions are peculiar. The room in question is the main office of a bank and is practically two stories in height, as shown by the sectional view in Fig. 1. A molding runs about the walls at about one-half the distance from floor to ceiling, this molding furnishing the only available location for the lamps to light the ceiling. This method of illumination was an after-thought of the architects, the molding being already constructed before the method was considered.

The ceiling of the room is laid out in large panels, the central panel being eleven feet square, and filled in with plain ground glass, being located directly under a skylight in the roof. Two problems therefore are involved in the general illumination: first, to light the ceiling, including the central glass panel, uniformly by lights placed along the molding; and second, to light the glass panel from above. The latter furnishes a very unusual problem in that it was not desired by the architects to use the artificial light through the central panel for illuminating purposes; but it is evident that unless lighted from above it would appear as a dark square in contrast to

FIG. I.—SECTION THROUGH ROOM.

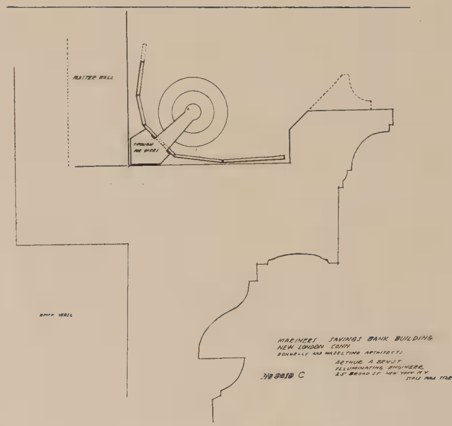


FIG. 3.—SYSTEM USED.

the other panels of the ceiling when lighted only from below. In fact, this ground glass panel surrounded by opaque plaster surfaces on one side is simply a Bunsen photometer screen on an enormous scale, and in order to have it appear uniform with the rest of the ceiling the transmitted illumination must be exactly equal to the reflected illumination.

The proposed arrangement of lights in the molding is shown in Fig. 2, which indicates a plain semi-cylindrical reflecting trough. This would have given a streak of light across the ceiling owing to its very unequal distribution. In place of this, therefore, a trough-shaped reflector was designed by I. P. Frink, having the outline shown in Figure 3. The intensity on the horizontal plane of the ceiling from this distribution is shown by the curve at the top of Fig. 4, which is a remarkably close approximation to uniformity. By adding a small molding shown by the dotted lines in Fig. 3, it was possible to use a maximum amount of reflecting surface and still keep both reflector and lamps entirely out of the range of vision. Sixteen candle-power lamps are to be used in these reflectors, placed twelve inches apart.

For illuminating the glass panel from above the only support for the lamps is on the side wall 18 inches above and 9 inches to the side of the panel. The original plans contemplat-

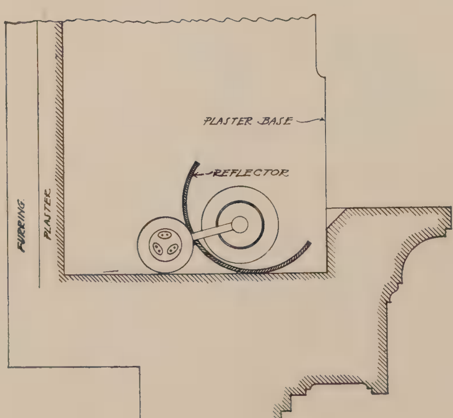


FIG. 2.—PROPOSED SYSTEM.

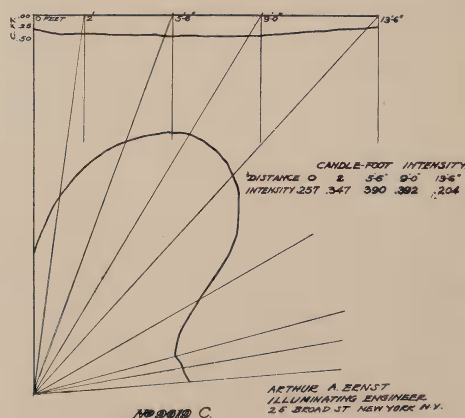


FIG. 4.—DISTRIBUTION CURVES OF SYSTEM USED (FIG. 3).

ed the use of a device shown in Fig. 5, consisting of a lamp placed horizontally, with a small curved reflecting surface above, an arrangement which

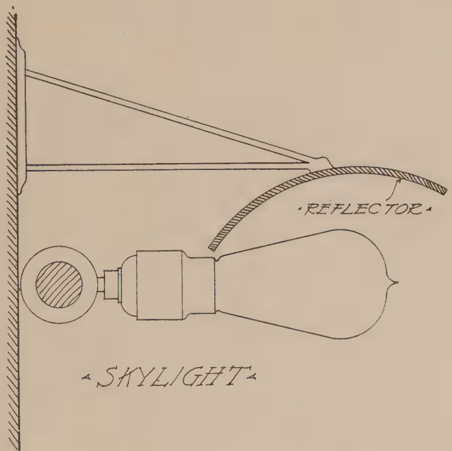


FIG. 5.—PROPOSED REFLECTOR.

must of necessity have given very uneven illumination over the panel. This was replaced with a trough-shaped reflector, also designed by Frink, as shown in cross section in Fig. 6. As the lamps are much nearer to the panel than those underneath, correspondingly lower candle powers will be used—probably six candle-power. Since the comparative reflecting and absorbing factors of the glass are unknown, the exact candle-power could not be predetermined. These lamps will also necessarily be frosted in order not to appear as bright points through the ground glass of the panel.

For working illumination, individual desk lamps will be used, and possibly side brackets may be added for the sake of decorative effect.

The case is one in which indirect lighting is particularly applicable, for the reason that the room will seldom be open to public use during that portion of the day when artificial light is required, and since also special light would be provided in any case for the book-keeping and other uses requiring close work. Efficiency therefore

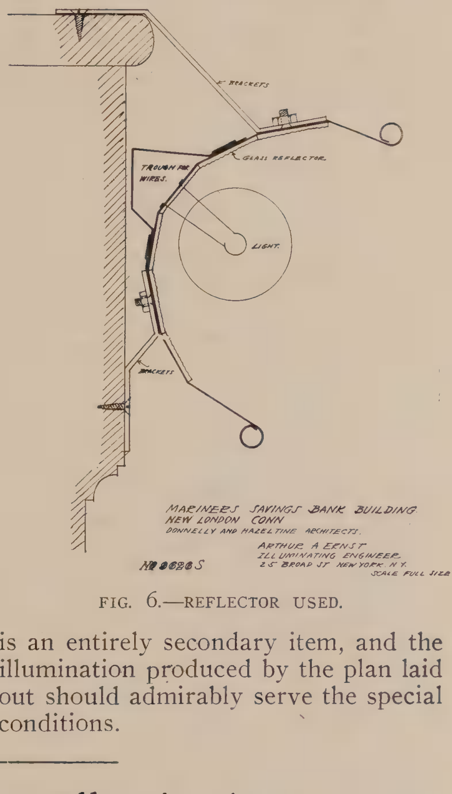


FIG. 6.—REFLECTOR USED.

is an entirely secondary item, and the illumination produced by the plan laid out should admirably serve the special conditions.

Curves of Uniform Illumination

By Ernest C. White.

Recent advances in methods of designing illumination have perhaps received no greater encouragement and foundation than is due to the careful compiling and publishing of photometric data by the promoters of new illuminants and the manufacturers of high grade accessories, such as reflectors and refracting globes. The accumulation of this data by the designer of illumination has formed the basis of all careful computations. It is with these computations themselves that we have to deal.

With the exception of vacuum tube lighting and special forms of illumination by transmitted light through a translucent medium, the law of inverse

squares must be applied in nearly all practical illumination even though the result of first calculations be modified by judgment and the general laws of diffuse reflection. It therefore appears that when curves are plotted using candle powers as radii or ordinates as the case may be, nothing more is accomplished than the graphical representation of data which must still be cumbersomely applied to actual problems. This is not quite true of the Rousseau Diagram which is used to facilitate certain calculations in regard to mean zonular candle-power. The fact remains, however, that the application of the law of inverse squares is by no means assisted by the Rousseau Diagram or the usual Polar Diagram, and reference to these forms for purposes of calculation must of necessity

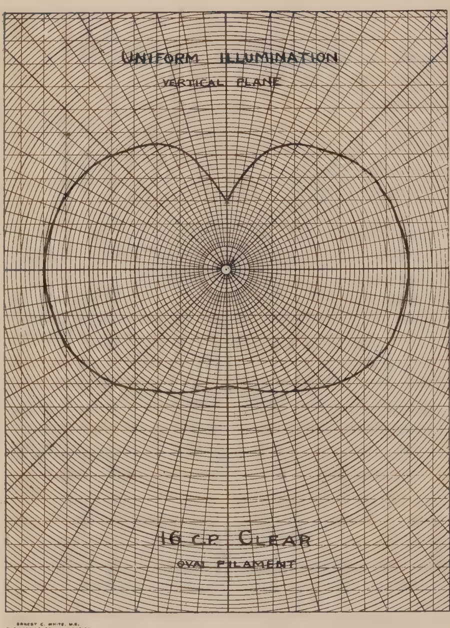


FIG. I.

be more approximate than reference to the original data from which they were plotted.

As a premise to the development of a more useful form of photometric data, in so far as the actual *distribution* of luminous flux is concerned, we may assume that a curve representing the distances in various directions at which the illumination is uniform is a long step towards the graphical representation of the law of inverse squares as applied to a given source. Taking the equation $d=\sqrt{\frac{L}{C}}$, in which L is the intensity of illumination at a distance d from a radiant of power C, it is observed that if L be considered constant d varies as $\sqrt{C}$. Assuming further that L is unity, that is, the illumination at unit distance from a source of unit power, we have $d=\sqrt{C}$ From this value we plot a polar diagram using the angles at which the radiant power is measured as in the usual form of curves, and for radii the square roots of the radiant powers, or to come nearer home, the square roots of the candle-powers observed in these directions. Fig. 1 represents such a curve plotted for the light distribution in a vertical plane from an ordinary pendant sixteen candle-power oval filament incandescent lamp with clear glass bulb.

It will now be evident that so long as the same scale is used in regard to distances this curve affords instant reference to the distances in all directions at which the illumination is one foot-candle—if the unit of distance is one foot and the unit of radiance one candle-power. We have now arrived at a very clear representation of the direct illumination produced by this source, but as the lamp would seldom be used at the distances represented it would still be necessary to make suitable calculations to arrive at the intensities at different distances. It is therefore necessary to provide a number of different scales to which this curve may be conveniently referred and which shall be of sufficient scope to permit direct reference within the limits of intensities ordinarily employed.

In Fig. 1 the unit distance, in this case one foot, is plotted as the radial length between every tenth circle, these lines being made heavier as is customary. If, now, it should be

necessary to plot the curve of a source of higher power to one-half of this radial scale, it is plain that the length formerly representing one foot will now represent a dimension of two feet, and, if read as one foot by reference to the same scale as used in the first case, the reading would be the distance in feet at which the direct illumination is, not one foot-candle, but four foot-candles. It is therefore evident that any convenient multiplication or division of scale provided for within the form of co-ordinants shown in Fig. 1 will result in convenient reference for only a few widely divergent intensities such as one-sixteenth, one-fourth, one, four, and sixteen foot-candles, etc.

Without going further into the deduction of the actual scales needed, attention is invited to Fig. 2 in which scales are provided which read in units of distance without subdivision for one-eighth, one-half, two, three-sixteenths, three-fourths, three, one-fourth, one, and four units of illumination, respectively, counting inwardly from the marginal scale. In actual use these scales give a wide range of approximate reference within limits of accuracy quite sufficient for all purposes, the personal equation being of some importance as usual when interpolation is necessary. It is to be observed, however, that the difference between intensities of adjacent values for which scales are provided are somewhat proportional to the absolute values of these intensities and this degree of subdivision is somewhat in harmony with Fechner's Law.

The actual selection of these values for which to provide scales is fully justified by convenience, which will be immediately recognized when it is recalled that sin. $60^\circ = \sqrt{3/4}$ and that sin. $45^\circ = \sqrt{1/2}$ so that when these scales are added to old forms of polar co-ordinates they may be laid off with no calculations whatever by simple reference to the proper intersections.

The use of these scales over a wide range is by no means complicated, it being only necessary to remember that when a fraction or multiple of the usual radial scale is employed in plotting the curve, the intensity of illumination corresponding to each scale must be multiplied by the square of the reciprocal of this fraction or multiple. For example, if one-half of the

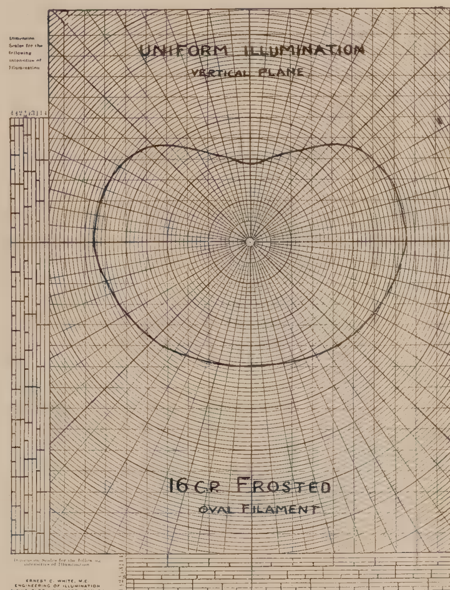


FIG. 2.

usual radial scale is employed, the scale which was formerly true for reference at one foot-candle intensity is then true at four foot-candles intensity and the scale labeled three-sixteenths is then true at three-fourths foot-candles intensity. For illuminants of very high power it is convenient to use one-tenth of the usual radiant scale, hence multiplying the printed intensities for the various scales by one hundred.

On the other hand, if it is desired to refer to any given curve at an intensity not provided for within the range corresponding to the radial scale to which the curve is plotted, it is only necessary to multiply or divide the intensity by the square of the factor used to multiply or subdivide the corresponding scale. For example, if it is desired to note the distance at which the sixteen candle power frosted lamp, for which curve is plotted in

Fig. 2, will give one-sixteenth foot-candle direct illumination, the divisions of the scale labeled one-fourth are simply read as two feet instead of one.

It has perhaps been considered by those whose acquaintance with the usual polar diagram of candle power distribution has not gone beyond the casual comparison of different luminants and the distribution effected by different accessories, that such curves afford convenient means of judging approximate effects. In fact, however, such curves are very misleading and it is perhaps safe to say that the general conception of the phenomena they represent is too often that which would be accurate if applied to the curves of uniform illumination herein described. It is the writer's experience that not only quicker calculations, but more accurate results, are possible through the use of this form of curve in the office. It is possible, however, that the lattter result is nothing more than the former, combined with ordinary human nature.

It will be observed that the use of horizontal and vertical rulings across the polar co-ordinates to facilitate reference to the marginal scales, gives rise to the well known perceptional illusion by which these straight lines appear to be curved until referred to a straight edge; this illusion being due to the tendency to over-estimate acute angles and under-estimate obtuse angles.

The Illumination of the Federal Building, Chicago

By J. E. Woodwell.

The features of interest to the illuminating engineer in the Federal Building in Chicago, are many and varied, both by reason of its size, 400 feet in length by 328 feet in width, with 650,000 square feet of floor area, and the extraordinary lighting requirements imposed by the architectural design. The exterior design of the structure is shown above, from which it will be at once evident that the building is admirably planned to receive the full benefit of natural light notwithstanding its location in the very heart of the business district of Chicago.

The lower three floors, with exception of the relatively small space occupied by the Sub-treasury, are assigned to the postal service, and the corner sections of the building which are used as working spaces for the sorting and distribution of the mails are covered by large skylights. The interior design is such that an excellent distribution of daylight is secured from these skylights on both the first and second floors, while the central rotunda is also planned for natural illumination.

FIG. 1.—FIRST FLOOR CORRIDOR.

FIG. 2.—UPPER CORRIDOR.

To furnish night lighting and to meet the exigencies of dark and cloudy days, the wiring system was planned to supply current to 20,000 incandescent lamps of 16 candle-power equivalent. This number of lamps was based upon the factors prevailing generally in office building practice in the City of Chicago. As a result of a careful study of the local conditions and requirements of each office and public space in the building with special reference to the fixture equipment, and by taking advantage of the most efficient accessories designed to direct and effectually distribute the light it was deemed practicable to install a fixture equipment providing for less than 15,000 lamps, the first equipment of which contained over 10,000 lamps of 16 candle-power. A later study under actual working conditions made it possible to supplant nearly all lamps of 16 candle-power by lamps of 4, 8 and 10 candle-power, so that the present lamp installation is the equivalent of 15,000 lamps of 8 candle-power. Exclusive of the receptacles for studded lamps and cord drops, 2,970 outlets in the building are furnished with fixtures which were installed at a total expense of about $50,000.

Notwithstanding the large number of fixtures the illumination of some of the prominent public spaces in the building is largely dependent upon

studded lamps. The first floor corridors, for instance, are illuminated by frosted lamps placed in the soffits of the arches. Lamps are also placed above the cove to furnish indirect lighting by reflection from the ceiling. In practice the service of the latter has been discontinued, the principal objects being the inefficiency of the method, the local glare of the lamps and the labor required to clean the lamps and reflecting surfaces.

The location of the soffit lamps made necessary by the architectural design of the corridor is unfortunate from the standpoint of illumination, and is unsuccessful especially with the use of either plain or frosted lamps alone. Considerable improvement has resulted, however, from the use of frosted lamps of lower candle-power and by securing a wider distribution by the use of Holophane pagoda reflectors.

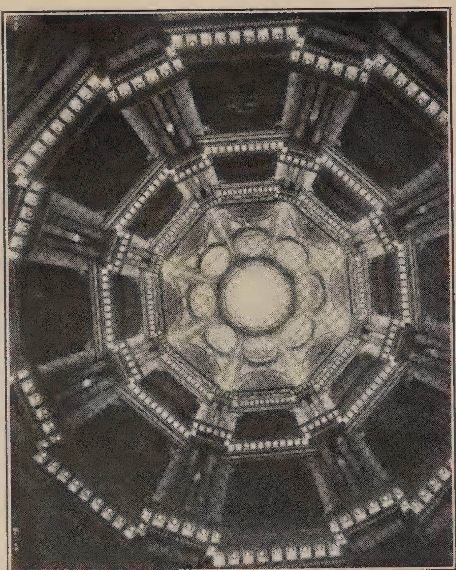


FIG. 3.—ROTUNDA, LOOKING FROM FIRST FLOOR TO DOME.

The main vestibules, finished in granite, are fittingly lighted by 12 fixtures of architectural design and generous proportions as shown in Fig. 16, each containing six 16 candle-power lamps in a sand-blasted globe.

The main object of architecural interest in the interior is the large rotunda, 63 feet in diameter, and 163 feet in height from the first floor to the corona. In plan the rotunda is octagonal, having eight pairs of massive columns rising one above the other to the point where the arches of the dome ceiling spring. The interior of the dome is richly ornamented, the classic designs in stucco work contrasting strongly with the severity of the massive columns. In the design and construction of the dome ample opportunity was afforded for securing the most elaborate electric lighting effects, and the result, though dignified and in keeping with the surroundings, is truly spectacular.

Fig. 3 shows the general arrangement of the lamps which are placed in rows around the dome at each landing set back in recesses formed in the architectural design. The strong reflection in the ceiling of the dome is produced by rows of lamps which are hidden by the upper cornice at the base of the dome. In the daytime natural light enters the rotunda through the grilled openings arranged in the eight circular windows, and is also strongly reflected from a spherical surface built up of steel and plaster, and suspended from the upper framework of the exterior dome over the circular opening in the ceiling of the rotunda.

It is intended to add eventually an appropriate painting upon the surface so that in viewing it from below it will appear framed in the circular opening of the inner dome. Fig. 4 clearly shows the grilled openings, the open center in the inner dome and the convex surface suspended above it. Artificial light will rarely be required in the daytime to illuminate the painting, but to secure equally effective illumination at night a row of 100 incandescent lamps has been placed around the circular opening of the inner dome but hidden from below. This arrangement is also clearly shown in Fig. 4.

Around the rotunda at each floor are corridors forming galleries between the inner and outer domes, which are

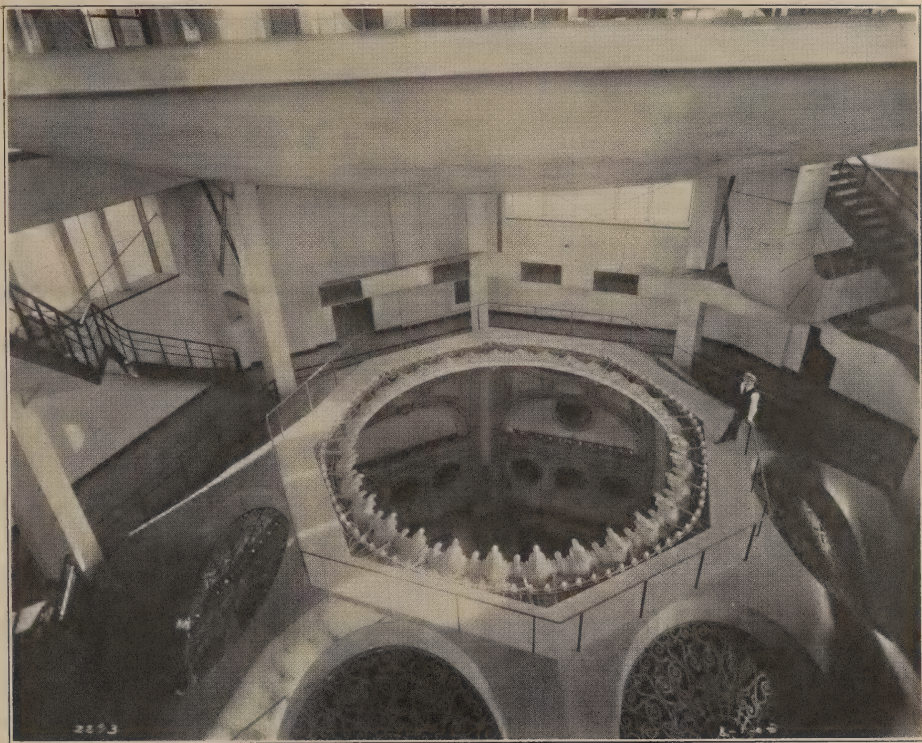


FIG. 4.—ABOVE THE DOME IN ROTUNDA.

illuminated by brackets as shown in Fig. 2. In the general scheme of illumination these fixtures play an important part in diffusing through the medium of Holophane globes a soft and mellow glow to relieve the intense contrast depicted in the photograph, Fig. 3, which was purposely taken without the aid of the gallery lights to show more clearly the decorative scheme for the rotunda.

FIG. 5.—INSIDE OF DOME.

In the rotunda illumination scheme just described, there are employed nearly 900 lamps of various candle-powers, mainly 4, 8 and 16. Experience has shown that ample illumination will be secured for all exposed positions by the use of lamps of 4 candle-power, the indirect lighting of the dome ceiling alone requiring a larger unit. Even with this reduction in candle-power, however, the daily use of this method of illumination is too costly to be practicable.

To supplement the weak natural light of dark days and for ordinary purposes the rotunda is illuminated by sixteen specially designed and rather unique electroliers of the type shown

FIG. 6.—BRACKET USED AROUND GALLERIES.

in Fig. 5. Eight of the fixtures are hung at the first and eight at the eighth floor level, over 100 feet above the first floor. The accompanying photograph, Fig. 6, does not do justice to the artistic appearance of the electroliers in position with the lights burning, but it will serve to show the manner in which the special design accords with the surrounding architectural features of the dome.

The brackets cost $400 apiece, are constructed of cast brass and weigh 750 pounds each. The globes, about 30 inches in diameter, are of leaded white ground glass, and are illuminated by 12 8-candle-power lamps inside, and are each enriched on the outside with a row of eighteen 8-candle-power white frosted lamps. A pleasing and artistic effect has been obtained by using ruby colored lamps on the interior which impart a rich red glow to the globe furnishing a contrast with the white frosted lamps which may be likened to the setting of a jewel.

The eight electroliers located on the first floor are of similar design but smaller and are not equipped with the frosted lamps on the exterior in order

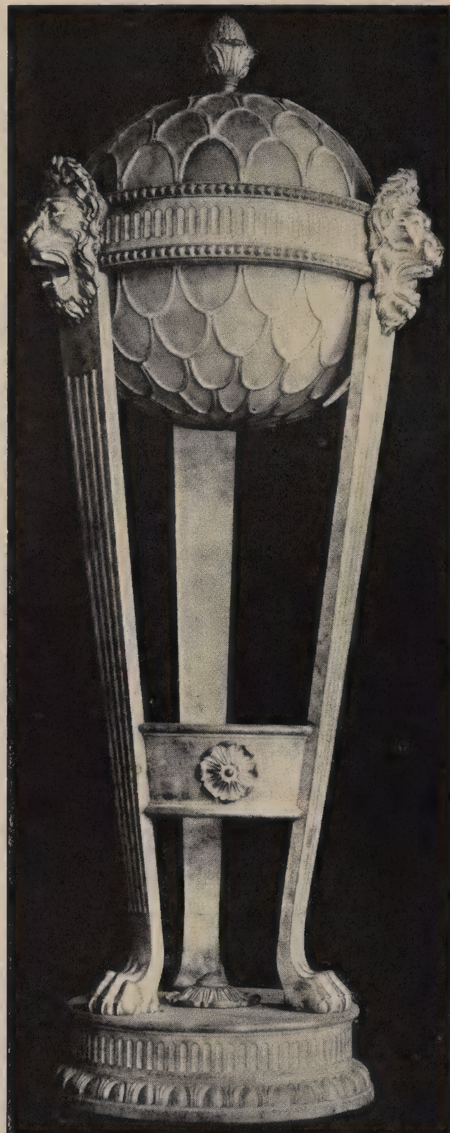


FIG. 7.—NEWELL POST FIXTURE.

to obviate the glare which would result from placing such light sources within the range of vision. The position of the lower electroliers and also of one of the newel post standards is clearly shown in Fig. 1. Fig. 7 shows the chaste and classic design of the newell post fixture which is designed to harmonize with the electroliers. In recesses behind the rotunda piers are placed bracket fixtures of the design

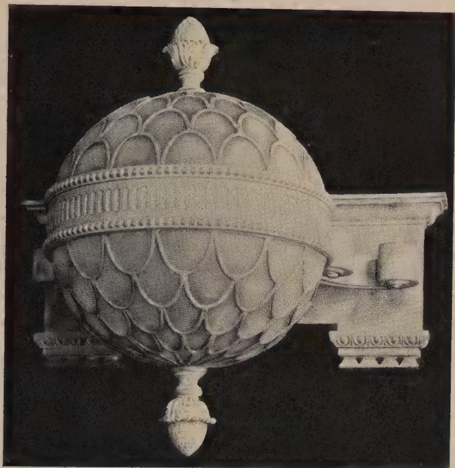


FIG. 8.—SYMMETRICAL FIXTURE IN ROTUNDA.

shown in Fig. 8. This symmetrical design was selected because the location of the fixture is such that it may be viewed from the stairway levels above it and also from the floor below.

The side corridors leading from the rotunda above the first floor, are not arched and are all effectively illuminated with various types of ceiling fixtures, some with simple globes and others of more elaborate design with stalactites surrounding a central globe.

FIG. 10.—TORCH BRACKET USED IN COURT ROOMS.

In all these cases Holophane globes are used to secure the proper diffusion and distribution of light.

In the lobby of the Sub-treasury, first floor, the illumination of both the public space and the writing tables is secured by seven brackets of the special design shown in Fig. 9.

FIG. 9.—LOBBY IN SUBTREASURY.

FIG. 11.—BRACKET IN COURT ROOMS.

FIG. 12.—CIRCUIT COURT ROOM.

The District and Circuit Court rooms are located on the sixth floor and are similar in size (about 50 by 80 feet), and decorative treatment. Fig. 12 shows one of the two court rooms in which a fixture of torch design is used. Fig. 10 shows the torch design more clearly, and also the arrangement of the frosted lamps surrounding the large opalescent flame tip which, when illuminated, enhances greatly the beauty of the design. The other two court rooms are fixtured with the design shown in Fig. 11, the ground glass ball taking the place of the flame tip. The fixtures in all of the court rooms are decorative in effect, the natural daylight illumination from windows on three sides and from the skylight of liberal size being generally sufficient. For night lighting, however, the fixtures are supplemented in each of the court rooms by two rows of lights in beam soffits and by fifty 16 candle-power lamps supported in special fixtures about five feet above the skylight, and equipped with pagoda reflectors. The result is a most

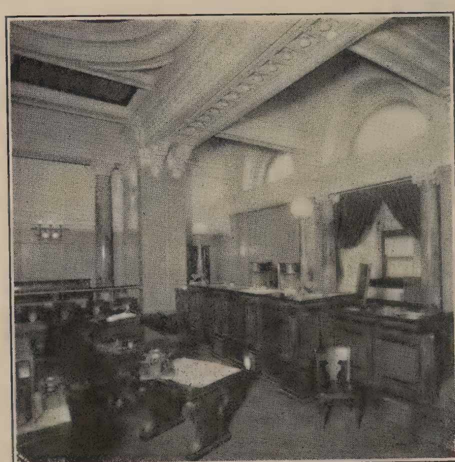


FIG. 13.—JUDGES' BENCH, COURT OF APPEALS.

FIG. 14.—PRIVATE CHAMBERS OF JUDGE GROSSCUP.

FIG. 15.—COURT OF APPEALS.

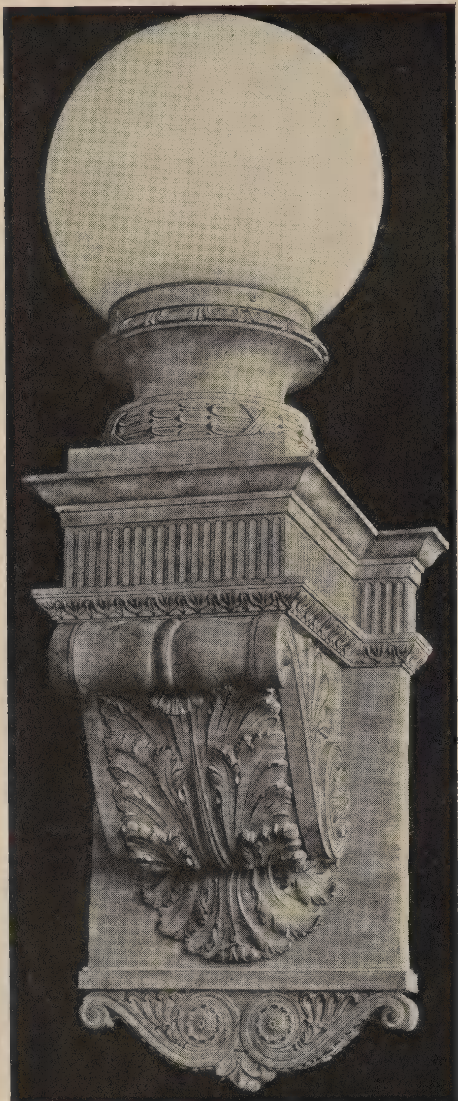


FIG. 16.—BRACKET IN MAIN VESTIBULE.

satisfactory illumination, nearly equivalent in effect to daylight. The finish of the court rooms in white marble is a material aid in this case in securing an excellent diffusion and in permitting the use of white frosted lamps of 8-candle power in the exposed locations.

The Court of Appeals is located on

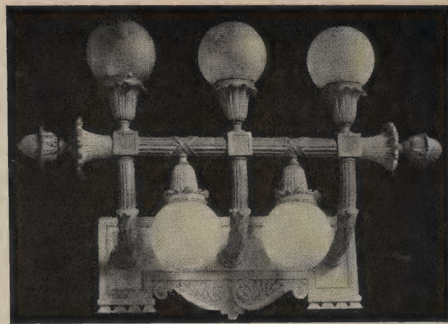


FIG. 17.—BRACKET IN COURT OF APPEALS.

the seventh floor, and is likewise arranged for skylight illumination. Indirect lighting is secured at night by lamps mounted some distance above the skylight in the same manner as described for the other court rooms. Studded lamps increase the overhead illumination above the Judge's bench as shown in Fig. 13, and lamps are also placed some distance behind the semicircular windows at the rear of the bench. Supplementing the above scheme, Judge's desk standards and special wall bracket fixtures are provided, each equipped with white ground and cut glass globes. Fig. 17 shows the special bracket design with back plate curved to fit the semi-circular rear wall of the court room.

The fixture feature of the important office rooms is typified by Fig. 14, which illustrates the private chambers occupied by Judge Grosscup. As shown in the photograph the general illumination secured from the fixtures is supplemented by a desk lamp for reading and writing purposes.

The designs for all the decorative fixtures illustrated were secured as the result of a competition between the designers of the most successful and competent fixture manufacturers, and were based upon a descriptive specification similar to that mentioned in connection with the illumination of the Federal Building, Indianapolis, Indiana.

FIG. I.—LOBBY.

The Illumination of the Hotel Blenheim, Atlantic City

The Hotel Blenheim is the latest and most magnificent addition to the numerous hotels of America's largest seaside resort. It is run in conjunction with its neighbor, the Marlborough, the combination forming one of the largest hotels in the world. Its claims to the attention of the illuminating engineer and architect, however, do not depend upon mere size. It embodies perhaps more novel features in architectural design, building constructions, interior decoration, and illumination, than can be found in any other building of approximately equal proportions in the United States.

In architectural design it is a departure from the classical designs which are the dominating fad with architects of the present time. The exterior proportions are admirably arranged to bring out its large dimensions without undue exaggeration. There is a delightful absence of ostentatious and "ginger-bread" ornamentation that is so generally in evidence in summer resort structures, the general impression being one of solidity and repose, forming a marked contrast to the usual air of gaudy flimsiness. The architectural features are, to a certain extent, the result of the method of construction used. The fact is worthy of special commendation, as architectural design is generally the result of slavish adherence to some supposed school or period, and is carried out with equal disregard for mechanical construction and surrounding conditions.

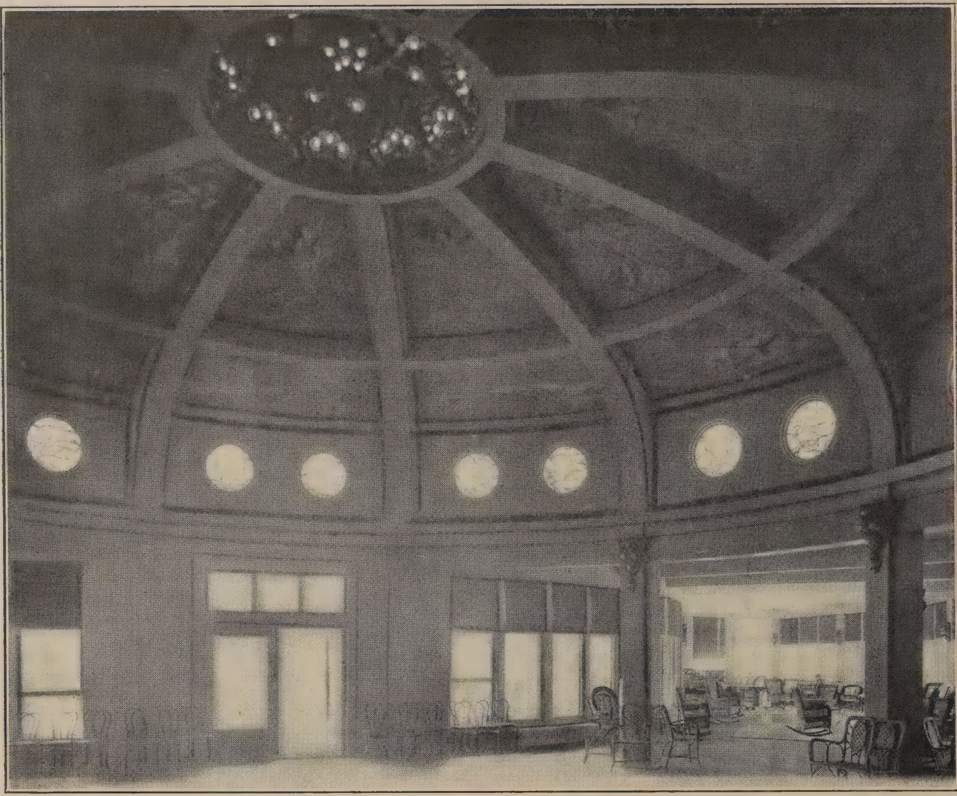


FIG. 2.—BALL-ROOM.

The building is of steel frame construction, the walls being of hollow brick plastered on the outside with cement. The cement is left its natural color, and the trimmings are of a light green, which gives an exceedingly pleasing combination of color.

The general design and decoration of the interior is commendable for the same reasons that apply to the exterior. Simplicity with elegance is the key-note. There is no shining expanse of imitation marble; no exaggerated and ponderous panels nor gilded mouldings; nothing flashy nor obtrusively ornate; an air of genuineness and artistic truth pervades the entire treatment. These features impress themselves the more from being found in the midst of the unmitigated Philistinism for which the American summer resort stands pre-eminent.

The illumination of the principal rooms is no exception to the general excellence of design, and shows the same independence of tradition, and adaptation to structural conditions and decorative design that characterizes the whole building. The most striking characteristic of the installation is the fact that the "fixture," in the shape of metal chandelier or wall bracket, is conspicuous by its absence. In all the important locations the illumination is entirely by lamps set in the ceiling or against the columns or pilasters.

Figure 1 shows the lobby looking toward the main wing of the building. This lobby is two stories in height, the second floor leading on to the balcony, as shown. The central portion of the ceiling is an octagonal panel, inclosed by the large columns which support the upper floors. This panel is decorated with a relief design in stucco, the central portion forming a

FIG. 3.—PILASTER DECORATION IN LOBBY.

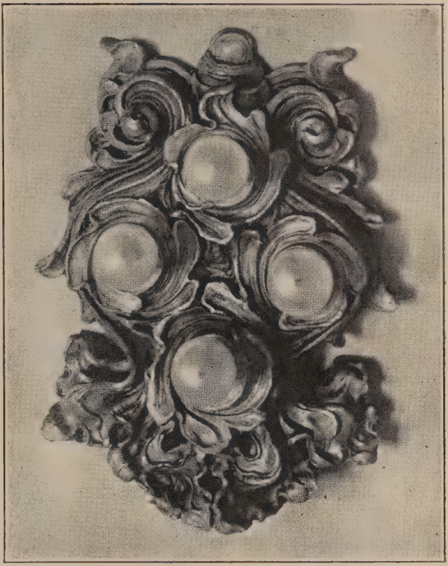


FIG. 4.—DECORATIVE LAMP HOLDER IN CORRIDOR.

FIG. 5.—MAIN CORRIDOR.

support for a large hemisphere as shown. This hemisphere is studded with incandescent lamps, as are various points in the general design. In the corners of the surrounding panels there are also stucco figures in which lamps are placed. Stucco relief ornaments serving as holders for lamps are attached to the pilasters and columns. As will be seen, the general *motif* of the ornaments is taken from marine life, and the coloring is in tints suggesting their origin.

The ball-room is in rotunda form, opening into the lobby on one side, and into corridors on two other sides. The illumination here is by lamps placed in relief ornaments forming the capitals of the pilasters, and studded in the central portion of the dome, as shown in Figure 2. The design in the dome is of stucco, using the conventional form of the sea-shell as a basis, and is delicately tinted to harmonize with the frescoes of the panel. The detail is shown in Figure 3.

The lighting of the corridors is by the same general method, *i. e.,* lamps set in relief ornaments placed upon the columns. A view of one of the corridors is shown in Figure 5. There is a possible justification for slight criticism here in not placing the lamps higher. It would seem both from the engineering and æsthetic standpoints that a better effect would be obtained if the lamps in their relief setting were placed as capitals to the pilasters, which would have raised them farther out of the direct line of vision and given the ornaments a more natural position.

The banquet hall and dining-room are located at the end of the wing opposite the lobby. The lighting in the main dining-room follows the general plan of the rooms just described, no pendant fixtures being used. In the four angles of the beams about the col-

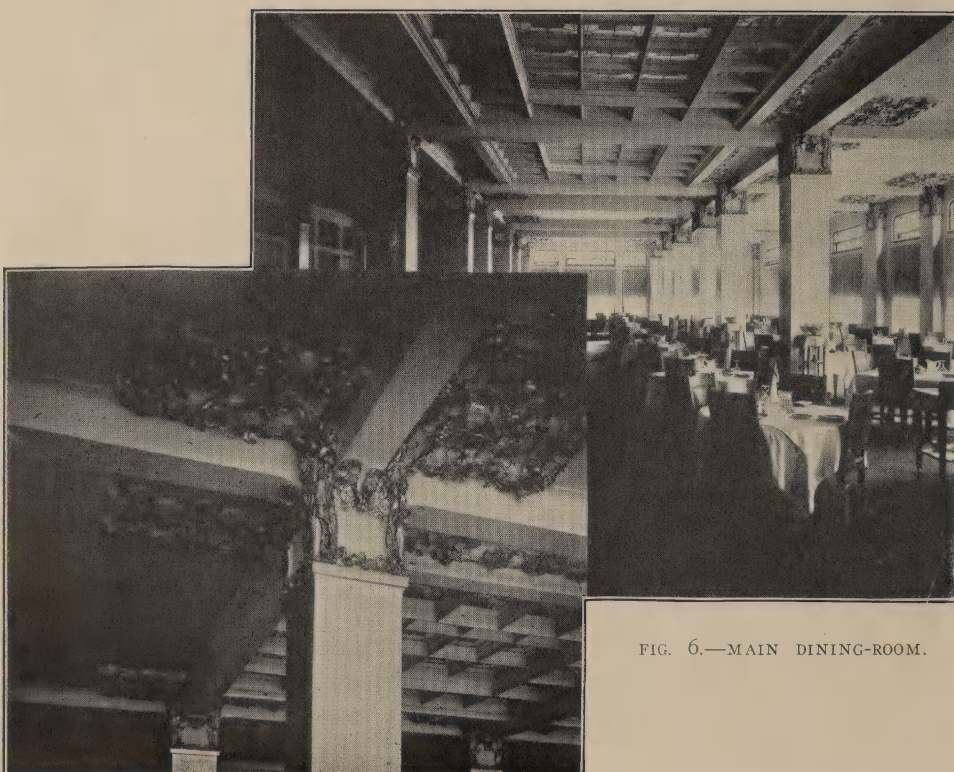


FIG. 6.—MAIN DINING-ROOM.

FIG. 7.—BANQUET-HALL.

umns, decorative relief designs in stucco are provided, with lamps placed at suitable points, so as to form a portion of the general design, as shown in Figure 6. The theme in this case is a grape arbor, and the coloring is made to harmonize with the general tone of the room, which is old blue.

In the banquet room the ornamentation which supplies the setting for the lamps is placed around the tops of the columns, the general color scheme being brown and yellow. The arrangement is shown in Figure 7.

In the corridors of the room floors the lighting is unfortunately very faulty, being produced by incandescent lamps placed in comparatively large frosted globes, so placed as to shine directly through the transoms of a considerable number of the rooms.

In the rooms themselves, however, a feature has been introduced which shows careful consideration of the guest's comfort. This is the placing of a bracket designed to imitate a candle-stick, with a small incandescent lamp in place of a candle, on each side of the mirror, as shown in Figure 8.

As a rule the installation is a splendid example of the contention that has so often been made that the metal chandelier or fixture is a relic of older systems of lighting, and has

FIG. 8.—LIGHTING OF BUREAUS.

no necessary connection with the almost unlimited adaptability of the electric light. Not only is the traditional fixture of metal entirely superfluous from an engineering standpoint, but as is so admirably shown in this case, equally unnecessary as an adjunct to a decorative scheme of the highest artistic excellence.

From the engineering standpoint it is possible that a slightly higher economy might have been obtained if foot-candles of illumination were the only results sought, but the installation is probably considerable more efficient than the majority of systems in which metal fixtures and decorative globes and shades are used to produce an ornamental effect. The ceilings in all cases are of light tint, the lobby being white, so that the factor of reflection is large. As evidence that the engineering features have not been entirely overlooked, however, lamps giving an effective downward distribution are used, the Shelby lamp being now installed.

The Pioneer Days of Electric Lighting

By G. Wilfred Pearce.

When the story of the beginning of the art of illuminating engineering shall have been fully told by the "corporals guard" of pioneers in electric lighting, the material will furnish matter for a book that will abound in interest for the youngmen who are reaping the fields which were prepared by those who entered the electrical fields a quarter of a century ago. It is hard for the juniors in illuminating engineering to believe that there are men active in the business to-day who a quarter of a century ago were regarded as little better in intellect than natural born fools, because they had embarked in a business which had against it the mighty power of the illuminating gas interests, the hostility of fire insurance corporations, and the other obstacles which old fogyism puts into the paths of progress. Eight important manufacturers of gas fixtures in the early days of the incandescent light refused to make electric fixtures to order, for the reason that they dreaded the ill-will of the gas light companies, which in those days dealt largely in gas fixtures, and whose officers looked upon those who made electric fixtures as enemies.

The first gas fixture house that embarked in electric fixtures kept the samples in a small room in a corner of its upper salesrooms, and employed a special man to sell the goods, and he

was instructed to be very careful not to let it be known to gas companies and plumbers that the house was making goods for the then three or four poor and struggling pioneers in the incandescent electric lighting business. After awhile the story that this concern was making electric fixtures got out among the gas lighting interests, and the result was that the firm was practically boycotted from one end of the country to the other; and as the electric fixture business of the world at that time would not have sufficed to keep fifty fixture workmen fully employed, the firm was obliged to plan for selling gas fixtures directly to consumers. Nobody in the gas fixture business at that time believed that the electric lighting business would ever become of consequence, and the same belief was common among makers of copper and brass goods.

The great illuminating engineering sharps of those days were the makers of electric gas lighting systems. Those men were the pioneer workers with insulated wire and combination joints. Any man who thought of putting the incandescent light in his house was usually advised by his architect to take the opinion of an expert in lighting gas jets by the electric spark. These men usually "rung in for commissions on the side" with gas fixture makers, and consequently they never failed to give incandescent electric lighting "a black eye." The dean of these gas-lighted-by-electricity mechanics was once called upon the president of a great life insurance company to pass upon plans that had been submitted to him for the installation of an incandescent electric light plant in a part of his new building. The then head salesman for the electrical lighting company—now the head of a tremendous aggregation of electrical industries—heard that the old electric gas lighting men had said that the manner in which he purposed to give blows full in the face of the incandescent lighting business, by reason of his report, would be the means of leading to the early death and burial of the "circus light business," by which name incandescent electric lighting was then known. So this then head salesman, being blessed with the wisdom of the serpent and the harmlessness of the dove, resolved to get close to the old gentleman and try to work him into making a report favorable to the putting of a plant into the insurance building. Bribery was no go. The old gentleman was as honest as daylight. Argument was tried and failed, as the gas lighting man was resolved beforehand that he would not change his mind. An offer of some shares of stock was rejected with scorn. But at last the salesman found a way out. It seemed that the gas man had been a brave and capable officer in the Civil War, but had been passed over for promotion by men deep in the wiles of how to make things go right in politics. The salesman being clever with his pen, got from the old man the story of his most thrilling adventures on the battlefield, and worked them up with illustrations, and had them published in a famous magazine. The matter was most interestingly written and elicited much favorable comment. In a day the gas engineer had become famous again. He was cheered at meetings of veterans, and made much of everywhere, and in the light of his gratitude to the man who had, as one might say, raised him from the dead to military life, he told the clever salesman for the electric light company to write a report favorable to its installation down town—not more than a million miles from the Equitable Assurance Building—and he would sign it. This was done, and the results justified all that was claimed for the plant, and the effect therefrom produced good seed afterward sown to increase an hundredfold, and thereby a great industry was put on its feet.

The first electric lighting fixtures for incandescent lamps was made by William Pearce, Boston, Mass., to the order of George Peabody, the great banker and philanthropist. The motif was a free treatment of stalks of Indian corn and running pumpkin vines.

Twenty-six lights were set in sockets fashioned like the stems of ears of corn. The bulbs were of moulded glass made to show kernels, and the sockets had leaves of sheet brass hammered to the likeness of corn shucks. The twenty-six lights symbolized the then twenty-six States of the Federal Union. This candelabra was about twelve feet high, and was finished in ormula. The object of its manufacture was to enable George Peabody to use it in his office for the purpose of enlisting capital in floating the electrical lighting inventions of J. W. Starr, of Cincinnati, Ohio. The candelabra was afterward taken to George Peabody's banking offices in London, where Michael Faraday saw it and made it the subject of a lecture.

In his boyhood, Mr. John Pierpont Morgan saw this lighting fixture in Peabody's office, where he was apprenticed to learn the banking business, and it is known that Mr. Morgan's interests in the electrical field, which now amounts to many million dollars, was first quickened by what his father and the aged George Peabody told him in his *young* manhood of the brilliant young American, Starr, who was the father of the incandescent electric lamp, and who died just on the eve of making a practical dynamo. This first incandescent electric lighting fixture was made about 1842. From the same patterns Moses Farmer, many years in charge of the electric fire alarm system of Boston, Mass., got out material for incandescent lighting fixtures for his own home, for which he invented an incandescent lighting system dependent upon a battery. This plant was seen by Edison when he was a telegrapher in Boston many years ago.

The first public stage lighting by the electric incandescent system was brought out at Portland, Maine, in the early forties, by the inventor of mannikins mechanically moved by electricity, that went through the mimicry of the battles of Concord and Bunker Hill. For the moonlight illumination of the march of the British from Boston to Lexington, the inventor produced a fine moonlight effect from the incandescent light, and a very fine sunlight effect from a glass sun illumined by electric light, reflected from cut glass prisms. Meyerbeer, the composer, heard of this sunlight effect at the American mannikin show, and sent over and got the right to use it for his opera "The Prophet." Dr. Colton, who brought out an electric tram car away back in 1846, and who survived to ride in modern trolley cars, said that he never saw a finer effect of electric lighting than at the mannikin show in Portland, Maine, away back in the forties.

Many incidents of like nature might be adduced to mark the growth of the art of illuminating engineering. In the old days, the illuminating engineers had to illuminate the minds of the public. The present writer's work as engineer of the first large interest in incandescent lighting was in great part devoted to press publicity, speaking at banquets, and before scientific societies, and in conducting controversies with fire underwriters, and the great financiers concerned for the perpetuation of the gas lighting business as the sole holder of the field in which the poor little bantling electricity was trying to pick up a few crumbs. And yet withal, the twin sisters of industrial progress blessed us—Art and Science. The best architects, faithful disciples of Art, were with us heart and soul from the beginning, and the sons of Science, the professors at the universities of technology and at the universities, lent us a helping hand, and by themselves fought many a hard battle for us, and so the art of illuminating engineering was not strangled in her cradle, but lived and grew to beauty and strength, and is now in the forefront of the progressive arts of mankind.

THE ILLUMINATING ENGINEER

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ILLUMINATING ENGINEERING WITH GAS

When the Illuminating Engineering Society was in process of formation the question of the relation of such an organization to the gas industry naturally arose. Those interested in electrical illumination were inclined to assume that the engineering of illumination belonged almost exclusively to their field; so much so indeed that the only adverse criticism that was made on the formation of the society arose from a fear that it might become a competitor of the American Institute of Electrical Engineers. The papers and discussions thus far presented are a sufficient refutation of this criticism and show that, if anything, the illuminating engineer is more urgently needed in the domain of gas lighting than in electrical illumination. While commercially the production of gas and electricity has been so frequently combined in this country as to greatly reduce genuine competition between producing companies, the contest for supremacy in cheapness and efficiency of the light produced continues unabated. This must always be the case, since such improvements are the result of scientific investigation and invention, and the scientist and inventor are not wholly actuated by commercial motives. This has resulted in each method of lighting retaining the field due to its own peculiar advantages: the electric light is more adaptable, requires less care, and produces less heat; to offset these advantages gas light is much more economical.

Having an economical advantage so largely in its favor, and apparently unattainable by any system of electric lighting, gas lighting has rested upon this single point of superiority; as a result it has assumed a secondary place in illumination—that is, it is used where electric lighting cannot be afforded. Gas illumination has, therefore, come to be recognized as proclaiming the user's inability to stand the greater expense of electric lighting, or his unwillingness to spend more money for a more elegant system of illumination. Recent discoveries in the production of electric light are of so revolutionary a nature as to very seriously threaten this chief vantage ground of gas lighting. The same principles which have been utilized in the cheapening of gas light, that is, the use of the peculiar properties of the so-called rare earths and metals, are at last being appropriated by the electrical interests, with the certainty that in the near future the efficiency of electric lighting will be at least doubled.

If it is thus to be driven from its stronghold of economy, gas lighting must go out in search of improvements of a decorative and æsthetic nature. That this fact has been recognized to some extent is evidenced by the advent of the inverted incandescent gas lamp. As we have before pointed out, the very name of this lamp indicates a reversal of the natural order of things. An inverted lamp is by its own definition a lamp burning upside down. The sole excuse for this inversion must be found in an attempt to compete with the electric lamp from the æsthetic standpoint. Undoubtedly many workers in this line have had in mind better distribution of the light from a burner so placed; but the assumption that it is

necessary to invert a burner in order to secure a downward distribution of light is contrary to the present conditions of the art. With the use of the modern reflectors it is possible to secure a greater variety of distribution, whether downward or sidewise, than can be obtained with the inverted burner. Whether these burners will develope an actually higher efficiency, and a less cost of maintenance than the upright burner, and whether the acknowledged inherent difficulties can be practically overcome, are questions upon which we do not care to pass judgment at the present time. Ample talent is being utilized to the utmost to perfect the burner, and the question of its place in illuminating engineering will depend upon future developments. It is now "up to" the gas lighting interests to bend every effort toward improving the *quality* of illumination, and the decorative features of lamps and fixtures. We believe that the present status of gas lighting is far from what it should be in these respects. There is no inherent reason at the present time for gas illumination accepting a position so admittedly inferior to that of electric lighting.

The earlier forms of the Welsbach burner, with their tall, straight chimney, and small fluted porcelain reflector, were hopelessly ugly. Add to this the greenish cast of the light which the mantles, particularly when old, gave forth, and their excessive glare, and the combination made a very poor second to the comparative elegance of the incandescent lamp with its usually small and more or less ornamental shade. Later an attempt was made to imitate the most defective form of electric lamp, so far as appearance is concerned; that is, the arc lamp. The impossibility of making the arc lamp decorative in appearance is evidenced by the fact that they are never used at the present time in positions where elegance is of prime importance. Nevertheless, the so-called "gas arc" was largely introduced and used, furnishing a peculiar example of a successful attempt to imitate the faults rather than the virtues of a competitor. Later the efficiency of incandescen gas burners was increased by the simple expedient of lengthening the mixing tube. This again rather diminished than increased the sightliness of the burner. The next step, however, was a long one in advance, from the æsthetic standpoint; this was the construction of the "air-hole" chimney, a construction which permitted cutting down the length of the chimney by half, and increasing its diameter, thus at the same time adding to its efficiency and appearance. The efficiency has thus been increased to such an extent that a portion of it can very well be sacrificed to quality; in other words, chimneys of defusing glass, such as opal or frosted, and of ornamental shape, can be substituted for the old straight side clear glass chimney.

Without disparaging the inverted burner, it may be safely asserted that the upright incandescent gas lamp can be made quite as decorative and elegant in appearance as the incandescent electric lamp. It is worth remarking also, that while the gas lamp manufacturer has been struggling to turn his lamp downward after the fashion of some electric lamps, the electrical fixture maker and decorative artist have been turning their electric lamps upward in an endeavor to imitate candles and gas flames. If there are any doubts as to the decorative possibilities of the best form of upright gas burners, they should at once be resolved by an inspection of the fixtures which we illustrated in our last issue, where similar designs for gas and electric lights were shown side by side. The inverted gas burner has unquestionably largely increased the decorative possibilities of gas lighting; and with the development of burners constructed to burn at downward angles, the possibilities in this line will be still further widened.

Considerable attention has also been given recently to devices for lighting and extinguishing gas lamps at a distance, thus giving them one of the

great advantages that has heretofore been monopolized by the electric light. This fact was deemed of such importance by the electric industries as to receive special attention at a recent gathering of the electric lamp manufacturers.

The moral which we wish to draw from this discussion is, that the gas lighting industry stands in especial need of the work of competent illuminating engineers. In making this statement we wish to emphasize the fact that the competent illuminating engineer must be conversant with the principles of decorative art as applied to illumination, and must consider illumination from the æsthetic point of view quite as much as from the purely commercial. By the selection and use of the best modern devices and with an intelligent consideration of the decorative features involved, there is no reason why gas lighting should not take its place as a first-class system of illumination, instead of filling the secondary place which it holds solely by virtue of its cheapness.

"NEW BUSINESS" CAMPAIGNS

In a previous issue we noted the formation of the Co-Operative Electrical Development Association. The object of this association is to co-ordinate the efforts of the various electrical industries toward increasing the sale of electric current and all the machinery and apparatus connected with its generation and distribution. An advertisement also appeared in our pages announcing an offer of one thousand dollars in prizes for the best articles on subject related to this purpose. The second of the prize articles to be published appears in this issue. Although a portion of the matter of this article does not directly concern illuminating engineering, it is so well expressed and contains so much matter of general interest that we gladly publish it in full.

Without reviewing this paper in detail, we wish particularly to commend the general policy which forms the basis of the argument, and that is, *to give the public good service.* There are many phrasings of this familiar statement that have become so familiar as to have often suffered the penalty of familiarity, the breeding of contempt. That "honesty is the best policy" has long been admitted, but often with many mental reservations. Lincoln's well known dictum stating the impossibility of "fooling all the people all the time," and Roosevelt's appeal for the "square deal," are expressions of the same general truth.

There is undoubtedly no field in which there is so great an opportunity for improving the conditions and service as in that of illumination, and any influence which is directed toward this end is worthy of every encouragement. A number of the largest central stations have already established an illuminating engineering department, and in one case of which we have personal knowledge the results from the commercial standpoint are most gratifying. The study of ways and means for loading the customer's current bill without giving adequate return in illumination must be absolutely discarded, and attention directed in the opposite direction of giving more and better illumination with less current. The contract that is ingeniously framed so that any considerable reduction in current will raise the actual total cost by a sliding scale scheme must likewise be abandoned. There are already in existence in two of the large cities incorporated companies, an important branch of whose business is to protect customers against such practices, and to see that they are not overcharged purposely or by unintentional errors which companies refuse to correct. The necessity of such services from out side parties is a very serious reflection upon the business methods of lighting companies, and is also a convincing proof that in the end all the people will not continue to be fooled. As a permanent investment, the square deal is the only one which is sure to bring continued dividends.

THE PASSING OF THE CARBON FILAMENT LAMP

Some eighteen months ago, in an article written for *The Central Station* under the caption "Is the Carbon Filament Lamp Doomed?" we reached a conclusion in the affirmative, and predicted that carbon must, in the near future, give way to substances better adapted to the transformation of electrical energy into light. This conclusion was based on the theoretical possibilities of the so-called rare metals, and the general proposition, that where improvement is theoretically possible, it will, sooner or later, become an accomplished fact. Comparatively little was publicly known at that time of the results of researches in this line. The tantalum lamp was soon after brought to public notice in this country, and within the past half year reports have been coming thick and fast of various discoveries and patents in this field, and of the formation of commercial companies for their exploitation. The so-called "metalized filament" was also publicly announced not long after this article appeared. The latest of these new processes claims a lamp of one watt per candle efficiency. To drop from four watts per candle, which is still not unusual with the carbon filament lamp, to one watt per candle, is not only revolutionary but startling; and yet there is theoretically no reason why this should not be accomplished. Lamps of this efficiency have already reached this country, and it is said will soon be placed on the market.

In the article referred to, we mentioned some experimental work in this line that had been done by a mining engineer of recognized ability, Mr. F. M. F. Cazin. His researches go back ten or twelve years, and some of his methods were developed to the stage of an attempt to manufacture on a commercial scale. Troubles among the members of the company seem to have brought this venture to an untimely close, and even prevented the actual results obtained from becoming known. It was claimed that lamps of 1.7 watts per candle had been made, showing an average life of 600 hours. Although Mr. Cazin has had many liberal offers to demonstrate the advantages claimed for this process, he seems to have preferred enjoying the sense of absolute possession of his patents more than the opportuuity of making them a commercial success, and while he has been dreaming of millions in the future, experimenters have been at work accomplishing practical results and making the rare-metal filament lamp a commercial entity. There seems to be several practical methods of producing filaments of the rare or infusible metals, and several metals of the group available for the purpose; so that the chances of a monopoly on improvements of this kind are very considerably reduced, and the supply of material increased proportionately.

OUR CONTRIBUTORS

It is always a matter of interest, and in many cases, especially with technical articles, a matter of importance to know something of the qualifications of the writer. The following information will therefore interest ILLUMINATING ENGINEER readers:

Mr. Arthur A. Ernst is president of the Engineering of Light and Illumination Company, New York, and devotes his entire time to illuminating engineering.

Mr. Ernest C. White is a practicing illuminating engineer, with offices in Winnipeg, Canada.

Mr. J. E. Woodwell is the Illuminating Engineer for the Treasury Department, United States Government, his official title being Inspector of Electric Lighting Plants.

Mr. George Wilfred Pearce is connected with the Financial Department of the New York *Sun*. He was formerly engaged in the manufacture of lighting fixtures, and has seen the electric light develop from a mere scientific curiosity to its present commanding position in the lighting world.

Research and Investigation

Conducted by THE ILLUMINATING ENGINEER

THE MOORE LIGHT

In our last issue, we gave a short "popular" description of the Moore Vacuum Tube system of illumination, expressing a belief that this form of light, which has been in an experimental stage for the past ten years, has at last reached a position where it is to be reckoned with as a commercial light source. In order to determine to what extent this belief was well founded, we have had an investigation carried out by The Electrical Testing Laboratories, the report of which follows:

Report No. 2259.

Report on Measurement of Illumination Produced by Moore Tube Nernst and Incandescent Electric Lamps.

Order No. 2241.

The tests covered by this report were made for THE ILLUMINATING ENGINEER under the general direction of Mr. E. Leavenworth Elliott. The lamps were installed in the Picture Department of the store of L. Bamberger and Company, Market street, Newark, N. J. The general arrangement of the space illuminated and the location of the illuminants is indicated in the attached blue print of a plan, available through the courtesy of the Moore Electrical Company. See Fig. 1.)

Measurements of illumination were made at seven points in a horizontal plane thirty-four inches (34″) above the floor. These test points were located in the space between the exhibition racks, whose illumination constituted the chief object of the installations. They are indicated on the diagram already referred to.

The ceiling of the illuminated space was metallic, finished in cream color. The walls and partitions were covered with red burlap, upon most of which pictures were mounted.

The MOORE TUBE was 179 feet in length and 1¾ inches in diameter. The light emitted by the tube was characterized by a representative of the Moore Electrical Company as of an "orange tint." The tube has been in service about one thousand (1,000) hours, having been installed March 16th, 1906.

The NERNST lamps were of the six glower, A. C. type, with opalescent globes of bluish tint. Within twenty-four (24) hours before the test they were equipped with new 250-volt glowers. All glowers were burning.

The INCANDESCENT lamps were wired to molding on the ceiling, with the exception of twenty (20) 16-candle-power lamps used with opaque reflectors for the illumination of certain swinging racks. These latter were of practically no utility in illuminating any of the stations investigated. The total equipment included eighty-eight (88) 8-candle-power lamps and twenty-five (25) 16-candle-power lamps. The bulbs of all the lamps were of clear glass and were cleaned immediately before the test.

The intensity of illumination was determined by means of a Weber photometer especially arranged for work of this character. This instrument, together with the instruments used in determining electrical conditions, were carefully verified in the laboratory of the Electrical Testing Laboratories at New York on the day of the test and on the following day.

All electrical values in connection with the MOORE TUBE and the NERNST lamps were determined by instruments belonging to the Electrical Testing Laboratories, placed in circuit upon the service during the test. Because of differences in wiring arrangements

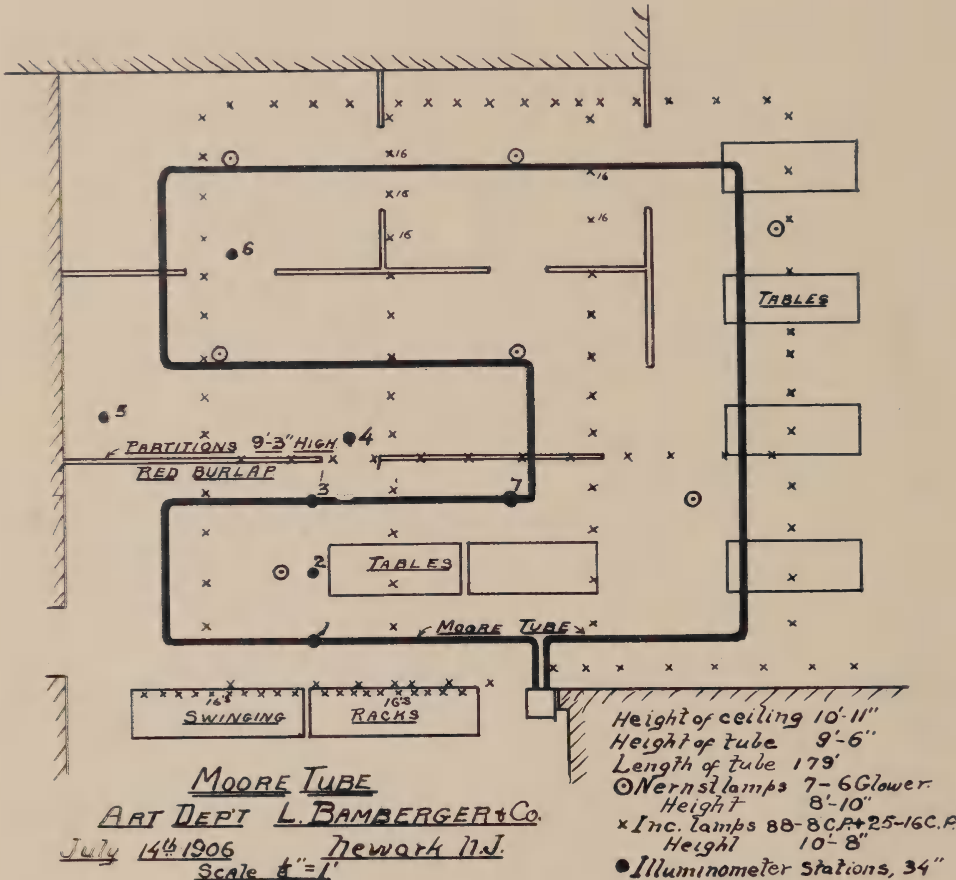

FIG. 1.—PLAN OF ROOM, SHOWING LOCATION OF LIGHT-SOURCES AND ILLUMINOMETER STATIONS.

for the INCANDESCENT lamps similar values could not be determined without great difficulty. Consequently it was decided to remove nineteen (19) of the lamps from their positions and by supplementary test, considering these lamps as representative of all those installed, determine with sufficient accuracy the total energy consumed by the INCANDESCENT lamps as installed. With this end in view the voltage conditions were carefully determined during the test and supplementary tests at Electrical Testing Laboratories upon the INCANDESCENT lamps were made at voltages so determined.

All the illuminants were used without reflecting devices of any kind.

RESULTS OF TEST.

Height of ceiling, ten feet, eleven inches (10', 11"). Plane investigated, horizontal, thirty-four inches (34") above floor.

NOTE 1.—As all instrument parts, as well as the operator, were below the plane in which measurements of illumination were made, low intensities, such as those found at Station 5, cannot be ascribed to objective interference.

NOTE 2.—The unit of illumination used in this report is known as the lux and is equivalent to the illumination produced on a plain surface by a source of one candle-power at a distance of one meter, the rays of light

falling upon the surface perpendicularly. One foot candle is equal to 10.76 luces.

NOTE 3.—All figures setting forth consumption of energy by the MOORE TUBE are measures of total energy consumed by the MOORE TUBE system, including all auxiliaries.

	Moore.	Nernst.	Incandescent.
Height of illuminant above floor.	9 ft. 6 in.	8 ft. 10 in.	10 ft. 8 in.
Number of units................	1 tube, 179 ft. long, 1¾ in. diameter.	7 6-glower lamps (250-volt glowers).	88 8-c.-p., 25 16-c.-p. lamps, clear bulbs.
System	60 cycle.	60 cycle.	60 cycle.
Average voltage of circuits during test	243	244	117
Kilowatts	3.15	3.92	4.13 (est.)
Volt-amperes	5640	3890	....
Indicated power factor..........	56%	Unity.	....

INTENSITY OF HORIZONTAL ILLUMINATION.

Test Station No.	Moore.	Nernst.	Incandescent.
1	68 luces	41 luces	21 luces
2	68	67	16
3	76	52	16
4	77	39	19
5	18	17	3
6	68	78	12
7	63	15	17
Average..................................	63	44	15
Average variation from mean—index of degree of uniformity	20.3%	41.7%	28.1%
Average luces per unit energy.................	20.0	11.2	3.6

SUPPLEMENTARY TEST ON INCANDESCENT LAMPS.

Lamp No.	Rated Volts.	Operating Volts. Tested at.	Candle-power.	Watts.	Watts per Candle.
1	No rating	117	7.2	31.5	4.37
2	No rating	117	6.4	30.9	4.82
3	115	117	6.3	32.9	5.22
4	115	117	8.0	33.1	4.14
5	115	117	8.1	33.5	4.13
6	114	117	6.5	33.2	5.11
7	No rating	117	7.0	31.9	4.56
8	No rating	117	7.0	31.9	4.56
9	115	117	7.7	33.1	4.30
10	No rating	117	6.4	31.3	4.90
11	115	117	7.7	33.2	4.31
12	No rating	117	4.3	27.3	6.34
13	115	117	9.6	36.4	3.79
14	117	117	7.4	32.1	4.33
15	No rating	117	6.2	29.1	4.70
Average..........................			7.1	32.3	4.62
1	118	117	12.2	52.4	4.29
2	115	117	15.0	50.6	3.38
3	115	117	13.7	55.6	4.06
4	118	117	13.5	49.2	3.65
5	115	117	15.5	50.8	3.28
Average..........................			14.0	51.7	3.73

ELECTRICAL TESTING LABORATORIES,
Preston S. Millar.

Checked by E. FITZ GERALD, July 18, 1906.

FIG. 2.—ILLUMINATION BY MOORE LIGHT, FROM PHOTOGRAPH.

FIG. 3.—ILLUMINATION BY NERNST LAMPS, FROM PHOTOGRAPH.

FIG. 4.—ILLUMINATION BY INCANDESCENT ELECTRIC LAMP, FROM PHOTOGRAPH.

The conditions under which the installation under investigation was made were particularly favorable for such a test. The proprietor of the store in which it is located has evidently been an investigator of illuminating problems himself, for the store might almost be called an "Illuminating Laboratory." All modern forms of illumination have been installed, and are still in place and ready for service, including Incandescent Gas (Gas Arcs), Incandescent Electric Lamps, Enclosed Arc Lamps, Nernst Lamps, and the Moore Tube. In the Art Department, where the Moore Tube is installed, there are not sufficient Arc Lamps nor Gas Arcs, however, to enable a just comparison to be made. but we hope in a future issue to be able to report comparison between the Moore Tube, the Enclosed Arc and the Mercury Vapor Lamp.

Reducing the results to comparative figures and round numbers, it appears that with equal consumption of current the Moore Tube has twice the illumination power of six-glower Nernst Lamps, and six times the value of Incandescent Lamps of 3.50 watts commercial efficiency. It will be noted from the tests of the incandescent lamps that their average efficiency was 3.73, which is probably a fair average of the regular 3.50 watt lamps during the total period of their life.

A considerably higher illumination could, of course, be obtained from the incandescent lamps by the use of any good reflector and this should be kept in mind in making the comparison. By such means it would be easy to double the illumination on the surface considered. On the other hand, it is equally possible to use a reflector with the Moore Tube. This is accomplished by simply silvering the upper half or coating it with white enamel or

opal glass. We expect also in a subsequent issue to publish tests upon tubes of this kind, and also upon the illumination from tubes giving white light.

The item of maintenance must also be considered in making comparisons of cost. The engineer of the building reported that the Moore Tube had given no trouble nor expense whatever since its installation. The period that has been in use (practically 1,000 hours) would have required at least 1½ complete renewals of the incandescent lamps, while in the case of the Nernst Lamps, we understand that the maintenance cost as determined by the Public Service Corporation of New Jersey is $0.01 per K. W. H.

The maintenance cost of the three systems for 1,000 hours would then have been as follows:

Moore	$0.00
Nernst	39.20
Incandescent	27.20

The original cost of installation of the Moore system we understand is substantially the same as the cost of ordinary arc or incandescent systems including the necessary wiring.

The visual effect of the illumination is a matter of paramount importance, and this cannot be fully expressed by any system of photometric measurements. While photographic processes do not give an exact representation of the visual effect, they furnish instructive data. The illustrations given in figures, 2, 3 and 4 bring out the characteristics of each system of illumination, but in an exaggerated form. The Moore light is surprisingly actinic in view of the decidedly reddish cast which it possesses. The tint of the light, however, is quite distinct from the orange-red light of flame or incandescent lamps, being of the cherry red order, indicating the presence of a considerable portion of blue rays. The photographs taken therefore are, as stated, more pronounced in their contrast than is the effect of the illumination on the eye. The difference is the diffusion of the light and in the effect of glare (halation) is, however, substantially accurate in the photographs, and they are valuable to this extent.

As mentioned in our previous article, the efficiency of the White Light System is much lower than that of the Standard Light. From photometric measurements made upon the intensity in a direction perpendicular to the tube, it seems probable that the efficiency is not over one-half that of the Standard Light. This difference is due to purely optical causes, as has been pointed out, and cannot, therefore, be improved by electrical or mechanical means. As an approximation to sun-light, however, it is remarkably close. In a portrait studio which has been equipped with the White Light, it is stated that artists working in water colors are enabled to work by the artificial light with exactly the same results as by day-light; and in a department store in which it has been installed, the salesmen state that it is equal to day-light for the purpose of matching colors.

The Moore system of light introduces some novel problems in photometry; thus, the "law of inverse squares" would hardly hold on account of the large extent of luminous surface, and the vexed question of "mean spherical candle-power" would seemingly need to be replaced with "mean cylindrical candle-power." The only satisfactory measurement is one of an actual illuminating value, such as was made in the above test.

It is needless to say that the Moore Light can never satisfy all conditions of illumination; but from the results obtained in the test, and from the experience gained from its use thus far, which practically does not extend beyond a year, it seems safe to say that there is a large field for its application.

Correspondence

FROM OUR LONDON CORRESPONDENT

TENDERS FOR ELECTRIC LIGHTING.

Considerable war is being waged on this side by gas and electric lighting companies to secure the public lighting of the streets of London. The authorities of one district, Westminster—or as the powers that be choose to call it, the City of Westminster—claiming that it has civic rights which are as old, or older, than the City of London, have just had under consideration two tenders, the first of the supply and fixing of flame arc lamps and lamp posts, to remain their property, and for the maintenance and lighting of the lamps on the following terms:

No charge to be made for the first 18 months and for the remaining 3½ years to be the same as at present charged for arc lamps, which would be as shown in Table I.

The alternative tender was for the supply and fixing of "Oriflamme" 9 ampere flame arc lamps and lamp-posts for the sum of $204.00, and for the lighting and maintenance of the lamps on the terms shown in Table II.

The lamps are to be lighted and maintained free for the first 18 months, and for the remaining 3½ years the sum of £17 15s. per lamp per annum. The offer to maintain the lamps free for the first 18 months is made because the system of lighting by flame arc lamps is new and the company tendering desire to gain practical experience of the best type of lamp; they venture the opinion that the candle-power would considerably exceed that specified and state that the streets would be more efficiently lighted with fifteen flame arc lamps than with twenty gas lamps of 900 candle-power. This special tender applies to the lighting of Parliament street and Whitehall.

The gas company tender was for the supply of lamp-columns and lamps where none now exist, for the sum of $81.60 per lamp, and for the maintenance and lighting of the whole of the lamps, at $72.24 per lamp per annum. At the time of writing no settlement had been made; there seems very

TABLE I.

June 1, 1906, to Dec. 1, 1907,	period 18	months	Free.
Dec. 1, 1901, to Dec. 1, 1908,	" 12	"	$102.44
Dec. 1, 1908, to Dec. 1, 1909,	" 12	"	101.90
Dec. 1, 1909, to Dec. 1, 1910,	" 12	"	101.38
Dec. 1, 1910, to June 1, 1911,	" 6	"	50.45
Total cost per lamp for five years			$356.17

or an average price per lamp per annum of $71.24.

TABLE II.

June 1, 1906, to Dec. 1, 1907,	period 18	months	Free.
Dec. 1, 1907, to Dec. 1, 1908,	" 12	"	$82.64
Dec. 1, 1908, to Dec. 1, 1909,	" 12	"	82.22
Dec. 1, 1909, to Dec. 1, 1910,	" 12	"	81.80
Dec. 1, 1910, to June 1, 1911,	" 6	"	40.68
Total cost per lamp for five years			$287.34

or an average price per annum of $57.46.

little doubt that the flame arc lamp here is still in an experimental stage, and that even the friends of the system are uncertain as to the practical results. The illumination is most brilliant, and the colors more nearly approaching brilliant sunshine. An installation has been set up at the foot of one of the London bridges where the traffic is very heavy. What the cost for energy may be we know not, and from the reports we have seen it is at present an unknown quantity.

COST OF ELECTRIC SUPPLY IN LONDON.

In a recent issue of the "Electrical Times" the editor gives in elaborate tabular form Electric Supply Costs and Records of Metropolitan (London and District) and Provincial Works. The calls upon space will not permit more than a brief reference, so we will omit what may be termed the financial side and glance only at the working results which include: costs per unit sold, average price obtained, etc. The undertakings are the property of the Local Municipal Plants and Private Companies. The table includes particulars of the following districts or parishes for the year ending March, 1905.

The companies give no particulars of the population of district supplied. The returns, as published in the journal named give most elaborate statistical information, but the foregoing will, we feel sure, be of interest to illuminating engineers in America, because it gives some idea of the magnitude of the electric lighting business in the City of London and suburban districts. The tables also include statistics of some 180 provincial undertakings, the property of local authorities, and upwards of 80 that are generated by public companies.

District.	Population.	Units Sold.	Works Cost.	Total Cost.	Price, Private Lighting.	Price, Public Lighting.	No. of 8 c.-p. Lamps.	Units Sold per Lamp.
Municipal Plants.			Penny.	Penny.	Penny.	Penny.	Lamps.	Units.
Battersea	180,000	1,554,920	1.04	1.44	2.99	2.35	70,403	29.5
Bermardsey	130,000	932,103	1.16	1.58	2.60	2.98	39,480	27.6
Fulham	150,000	1,865,008	1.01	1.33	3.12	1.54	71,645	29.6
Hackney	230,000	2,548,803	.57	.88	3.09	1.64	111,437	24.7
Hammersmith ...	114,200	2,948,633	.89	1.21	2.94	1.54	98,369	31.0
Hampstead	81,900	3,564,411	1.28	1.84	4.08	2.69	240,922	15.7
Islington	361,000	3,097,064	1.69	2.21	4.20	3.50	120,473	27.6
Poplar	168,800	2,331,927	.93	1.25	2.45	1.50	108,596	24.8
Shoreditch	118,700	3,536,497	1.54	1.83	3.13	2.51	190,320	19.8
Sarthwork	121,900	857,840	1.54	1.92	3.54	2.52	35,360	25.5
Stepney	298,600	3,425,153	.85	1.10	2.33	1.55	123,532	33.1
St. Pancras	235,300	5,596,816	1.05	1.35	3.20	1.61	270,863	21.7
Private Companies.								
Branston	....	2,624,380	1.07	1.97	4.43	....	188,586	14.6
Charing Cross ..	....	15,483,157	.97	1.57	3.06	2.90	824,494	20.2
Chelsea	....	3,222,038	1.23	1.78	4.22	....	221,809	15.0
City of London..	....	17,624,110	.84	1.43	3.29	2.48	759,902	24.4
County of London	....	8,614,187	1.01	1.64	3.72	....	656,778	14.2
Kensington	....	4,807,221	1.36	2.27	3.72	2.50	326,827	15.2
London	....	13,042,932	.65	.95	....	....	260,277	....
Metropolitan	....	14,079,160	1.05	1.84	4.38	....	607,762	18.5
Notting Hill	....	1,711,955	.95	2.05	4.74	2.50	143,102	12.5
South London ..	....	10,144,995	.88	1.04	....	....	120,412	....
South Metropolitan	....	2,144,316	.86	1.49	3.74	....	125,674	18.3
St. James	....	7,815,545	1.11	1.84	3.44	2.37	286,674	27.9
Westminster	....	14,899,170	1.12	1.75	3.87	2.02	764,930	20.1

HOW TO BURN GAS.

It has become quite the vogue here for gas managers to give lectures upon gas and its uses. Quite recently the manager of a North County gas works lectured before a large audience; he traced the evolution of the "fish-tail" from the "rat-tail" burner, and described both argand and regenerative burners, leading up to the burner of to-day, such as those of the Welsbach Incandescent Company; he compared the light given by such burners with good flat-flame burners, which a few years back were universally used in this country, and consumed, say five cubic feet of gas per hour; such burners yielded about 3 candles per cubic foot, whilst a Welsbach C burner gave a 17.1 candle per cubic foot, a Kern burner 25 candles, and a Welsbach self-intensifying burner would give 30 candles per foot.

The average consumer seems to have no idea of the loss in effective illumination through the use of unsuitable globes; it is of course well to utilize globes to soften light, but not to obscure and reduce illumination. It is strange that, with all the very apparent advantages of the Holophane globes and shades, they are but little used on this side of the Atlantic. The English housewife objects to them because they are such a trouble to clean; she quite ignores the beautiful and economical illumination given by the facets of glass. In towns with us the atmosphere is dull and too often smoky, so that the Holophanes would require considerable and constant attention. In these days, so-called artistic effect takes the place of practical utility, and Mrs. Newly-Wed prefers to have a shade for her incandescent lamps which accords in her judgment with the hangings codecorations, be they green, yellow, or red, very usual art colors, but not at all such as should be used to protect the eye from the too strong illumination of the incandescent gas mantle.

COSTS OF DOMESTIC LIGHTING

No doubt in America, as in the sister country, comparisons are still made between electric and gas lighting; some of the imbecility and bitterness have passed off, but each side still "backs their own horse." Here is what a gas man has to say about cost:

Style Burner.	Cubic Feet.	Cost, Cents.
Flat-flame	332	(0.16)
Argand	312	(0.13 to 0.15)
Welsbach C	58	(0.03)
Welsbach-Kern ...	40	(0.03)
Self-intensifying ..	33	less than (0.02)

The figures show the cost to produce a light equal to 1,000 candles for one hour by the use of various burners enumerated, gas being sold at 40 cents per 1,000 cubic feet.

Putting the figures somewhat different we show the candle-power and duration of illumination of one penny (2 cents), worth of gas:

Flat-flame........	15	candles	for	8½	hours
Argand	16	"	"	8½	"
Welsbach C	60	"	"	12	"
Welsbach-Kern..	100	"	"	10½	"
Self-intensifying.	150	"	"	8½	"

It will, no doubt, be somewhat of a surprise to readers of THE ILLUMINATING ENGINEER to hear of gas being manufactured and sold at 40 cents per 1,000 cubic feet; not only is this done, but the company in question has paid maximum dividends for many years and set aside the reserve fund permitted by the Parliamentary statutes under which it operates. It is only fair to mention that the works are contiguous to Great Britain's gas coal fields, an consequently good coal is cheap.

LEAD WOOL.

Engineers who occasionally have to buy cast iron pipe will hail with much satisfaction the new jointing material known as Lead Wool. It has, of course, from time immemorial, been the custom to run all points of cast iron pipes, after yarn caulking, in mol-

ten lead, with all its attendant disadvantages, *nous avons changer tout Cela* for with Lead Wool no heat is needed. The pipes are joined as usual and the lead, in fine strands cut by patent machinery, is simply twisted round the pipe, sufficient strands, or threads, being used to fill the annular space in the socket of the pipe left after yarning; the joint is set up with the ordinary tools. The setting makes a homogeneous joint and the threads of lead become solid; only about half the quantity of lead is required; there is great saving in labor and no waste. Lead wool is now being manufactured in England and we believe that it has already been introduced into America.

INSTITUTION OF ELECTRICAL ENGINEERS.

At a recent meeting of the Institution of Electrical Engineers on "Long Flame Arcs," in the course of the discussion a speaker said: "The wattage consumption of existing flame lamps—800 watts—was far too high for general use in the streets of smaller towns. There were indeed very few towns where the streets were of sufficient width or importance to warrant the erection of such large units of light. He expressed the opinion that what was really required was a reliable flame arc with a consumption of about 250 to 300 watts. Another speaker quoted figures showing the costs per 1,000 candle-power hour with current at 2d. (4 cents) per hour:

Lamp.	Watts.	Cost per 1,000 c.-p. hours.
Oriflamme	350	.8 cents
Nernst	350	1.1 "
Excello	470	1.1 "
Santoni	420	1.4 "
Carbone	1,000	2.0 "

The last mentioned lamp is on its trial and opinions seem to differ very much as to its usefulness and adaptability for street illumination. The defects of flame arc may be summed up thus:

The flickering noticeable in all chemical carbon lamps; the poisonous fumes given off—the ash or residuum from the chemical arc being much greater than from a high voltage flame arc lamp. The ash from a 10 ampere Carbone, using chemical carbon, is many times greater than with pure carbon, and as the globes cannot be entirely closed in the life of the carbons is very short. The light is useless in positions where selection or appreciation of colors is necessary. These Carbone flame arc lamps seem to have a *pied de terre* only for the illumination of large spaces, railway stations, and outside lamps for theaters; but for inside illumination they are most unsuitable.

CHAS. W. HASTINGS.
[Editor *Gas Engineers' Magazine.*]

FROM OUR READERS

Editor ILLUMINATING ENGINEER.

SIR:—

There seems to have been a good deal of misunderstanding with regard to the article by Mr. Cravath and myself on the street lighting of Los Angeles. The writers did not advocate this system on the score of efficiency as they pointed out it was very inefficient, being equivalent to one arc light every twenty-five feet. From every standpoint, however, except that of efficiency it is to be recommended inasmuch as the light is soft and easy in the eyes; the illumination on the street is very good and the artistic effects can hardly be improved. The photographs do not bring these points out well, but for anyone who has ever compared this with any other system of lighting, the difference is very marked indeed. The system, of course, is available only where the streets are used for business purposes and would not be suitable for residential districts as the efficiency would be altogether too low. The efficiency of the system, as at present installed, could doubtless be increased 50 per cent. by a very few slight changes.

V. R. LANSINGH.

As bearing upon the matter treated of in Mr. Lansingh's letter the following items from a Los Angeles paper will be of interest:

Because the city lighting expense is entirely out of proportion with that of street sweeping, sprinkling and other municipal necessities, the Board of Public Works decided to recommend to the City Council that property owners along Broadway, Spring, Hill and Main streets and all other streets where the ornamental lighting post is to be installed contribute to the cost of lighting.

It is the opinion of the board that property owners should pay two-thirds of the cost and the city one-third. The ornamental posts were advocated because of the improvement which it made to the property. Inasmuch as the property owner reaps the benefit the board thinks he is the one rather than the taxpayer in general who should shoulder the larger part of the expense.

Assistant City Attorney Hewitt has rendered an opinion that it is within the power of the board to make specifications for lighting of these streets. Monday the board will advertise for bids. The specifications will include a reduced candle-power, fewer lights and shorter hours of lighting as well as one for the same system of lighting that has been in vogue on Broadway during the past year.

In spite of the seeming lack of success of the Los Angeles experiment other cities seem to be inclined to take up the matter of artistic street lighting. In our Miscelloneous News Section will be found an account of a movement begun by the city authorities in Oakland, Cal., having in view the same general scheme that has been tried in Los Angeles; and in our last issue there was an item in the same department describing a similar movement in the town of Niagara Falls. That more efficient fixtures should be designed does not admit of discussion, and those contemplating such improvements should make this a special study.

To the Editor of the ILLUMINATING ENGINEER.

SIR:—

On page 259 of the June issue of the ILLUMINATING ENGINEER you showed two photographs giving different methods of lighting a desk, with criticisms on the same. Permit us to call your attention to the following facts:

In the first place, the photographs were both taken with the camera placed at a considerable distance from the desk. This does not represent the actual conditions of working inasmuch as a person sits directly at desk and not several feet away. For this reason the light shown in Figure 1 would not be visible in the camera but if a person were seated at the desk the light would strike his eye although he would not be looking at it. This is actually proved by experiment.

In Figure 2 the camera was placed horizontally and considerably back from the desk. The person would, of course, be directly at the desk and looking down, consequently, the halation of the plate, which shows clearly in Figure 2, does not actually represent the effect on the eyes of a person seated at the desk. If a man were seated at the desk in Figure 2 his eyebrows would shade the light from his eyes so that in this case working would be very easy.

It is probably impossible to get, with a camera, the conditions which actually exist when a man is working at the desk and for this reason such photographs are deceptive. We still do not see any reason to change our ideas as to the relative advantage of the two methods for desk lighting.

J. R. CRAVATH,
V. R. LANSINGH.

July 23rd, 1906.

Facts and Fancies

SOME INTERESTING FIGURES

There is no more exaggerated case of false economy than that of requiring people to work by poor illumination. In comparison with the cost of wages, the cost of light is trifling. Thus, suppose a workman is getting two dollars for ten hours' work; this is a rate of 20c. an hour, or one-third of a cent a minute. With electric current at 10c. a unit (WH), which is an average price when purchased of lighting companies in small amounts, the ordinary 16-candle-power lamp costs practically .6 of a cent an hour, or 6c. for ten hours. As the workman's time is one-third of a cent an hour the cost of the lamp for all day is equal to 18 minutes of the workman's time. This may be considered an extreme case, that is, a minimum rate of wages and a maximum cost of light. Take the case of a skilled workman receiving, say, five dollars for eight hours' work, which is a little over one cent per hour; and suppose the electric current is generated in the factory, in which case two cents per unit would cover the cost. The cost of a 16-candle-power lamp for eight hours would then be practically one cent; thus the cost of a lamp for an eight-hour day would be equivalent to the workman's wages for one minute; and yet there are thousands of skilled laborers handicapped by being compelled to work with insufficient and ill-directed illumination.

Another interesting computation, and one which is commonly overlooked by the users of electric lamps, is the small part which the cost of the lamp plays in the total cost of illumination. Thus, taking the highest retail price of a 16-candle-power lamp, which is twenty cents, and the average cost of current as ten cents, the average life of the lamp may be taken as 600 hours, and its current consumption as 56 watts. At this rate the lamp consumes practically 3/10c. worth of current per hour, and during its life will therefore consume three dollars worth of current; the cost of the lamp is, therefore, only 6 2/3% of the total bill, or in other words, the current consumed costs fifteen times as much as the lamp. Taking the figures which would hold in large installations where the cost of the lamp may be placed at 15c. and the cost of the current at 5c.; the cost of operating would then be practically ¼c. per hour, and for 600 hours, $1.50. In this case the cost of the lamp is 10% of the bill. The false economy of buying lamps that have a short life, or consume more current than they should, or of burning lamps until they have become blackened by use, is thus apparent.

PERVERTED TECHNICALITIES

The Electrical Review (London).

What queer things the lay press sometimes says about electrical matters. A Yorkshire daily recently spoke of writing off a certain sum for "degenerators and transformers." A Dundee paper said that distribution charges would be "higher with 6,000 volts than with the present system." But a "Special for the *Daily Mail* (Hull) excels in turgid gush anything that we have seen for a long time. It deals with the Hull Tramways power station.

"We must see how the mighty boilers are fed which work the stupendous engines" (300 kw.!). They are fed with coal by way of "troughs, at the bottom of which revolves a long screw, working on the same principle as the screw in a mincing machine"—how apt a similie!

The dynamo is "to put it simply, in this case, a huge horseshoe magnet by means of which the electricity is generated"—apt again, you see; hence the horse-power! Next the armature: "The wonderful thing is that the revolutions of the copper-covered spindle of iron disks possess the power to intensify the electricity. By passing through coils round the magnet the electricity generated becomes more intensified still. By this time the electricity in the 'field' has reached 450 h.-p.; the 'field' is saturated, and can hold no more. Thus it comes about that the current finds itself passing along cables to a great switchboard, where it is distributed by a simple but ingenious contrivance to other cables, which convey it to certain sections of the tram system, from which it is poured into the rails themselves."

ELECTRIC LIGHTING IN THE FAR NORTH

The light of the midnight sun is not usually thought of in connection with electric lighting, and yet the remotest parts of the earth are not strangers to some of the most modern devices of the present time, and there is always a particular fascination in the presence or use in any unusual or out-of-the-way place of devices of luxuries which are quite common near the centers of civilization. The following from the *Journal of Electricity, Power and Gas,* is a case in point:

Returning to Winnipeg, Man., from the Mackenzie River district in the Northwest Territories, where he has charge of the affairs of the Hudson Bay Company, Thomas Anderson gave some details of life near the Arctic circle. The inhabitants are chiefly Indians, but they are prosperous. Mr. Anderson has headquarters at Fort Simpson on the Mackenzie River. Speaking of Fort Simpson, Mr. Anderson is quoted in the Winnipeg *Free Press* of recent date as follows:

"A noteworthy feature is the fact that we have an electric light plant. The plant is operated by the engineer who has charge of the boats in the summer. The light is used for illumination in the stores, offices and dwellings and is in use all winter. When summer comes the boats are in use, and the long days render artificial light unnecessary. During the summer at Fort Simpson there is no real darkness, but about four hours of twilight. When we push down the river to the Arctic we reach the land of the midnight sun, where for weeks there is continuous day. We reach this region after a trip of about 700 miles."

LIGHT-HOUSES

It is probable that the use of light-houses is as old as the art of navigation, and as navigation became more and more a factor in the commercial importance of a country, the advantages of using the highest obtainable intensity of light for this purpose became of corresponding importance. It will no doubt surprise many of our readers, however, to learn that an ordinary sea coal fire was the light source in use in at least one of the English light-houses, as late as 1822. The coal fire was supplanted by oil lamps, and glass reflectors were used as far back as 1780. It is equally surprising to know that an electric lamp "giving a more brilliant light than had ever before been known, and supplied by a magneto electric machine designed by Prof. Holmes, was successfully tried in one of the English light-houses in December, 1856, and another lamp of a similar nature, designed by H. Wilder, was used in 1866. Gas was not successfully used until July, 1869. An electric installation designed by Siemens was used at the Lizards in March, 1876, the year which may be considered the starting point of the development of the electric lamp. The period between the final disappearance of the coal fire, and the first appearance of an electric lamp supplied by a mechanically generated electric current, is therefore only 34 years.

A NEW COMPARATIVE ILLUMINOMETER

The most needed instrument in the field of illuminating engineering today is a cheap, portable, and reasonably accurate illuminometer, and all attempt toward filling this need should be encouraged as much as possible. A distinction may be drawn between a *measuring* illuminometer, that is, one capable of giving results in foot-candles, and a *comparative* illuminometer, or one which will give relative values only. Of course, the former is the more desirable instrument, but far more difficult of successful construction, while the latter would be of great practical use in many cases. A very simple device of this latter description is that of Mr. M. S. Hopkins, of Columbus, O. It consists simply of a brass tube about 18 inches long fitted to receive an electric lamp bulb at one end and provided with a screen at the other. This screen consists of a metallic cap having a star-shaped opening in it, on the outside of which is placed a piece of tracing paper. In the center of the tube there is fitted an iris diaphragm, such as is commonly used in photographic lenses. In using the in-

strument, the electric lamp is connected to the regular circuit, and the iris diaphragm turned by means of a ring surrounding the tube until the screen shows as nearly as possible equal illumination. An arbitrary scale is arranged on the tube showing the points at which the diaphragm is set. The instrument is available for comparing the illumination at any given point with different installations of lamps, accessories, etc. One advantage of the instrument is its simplicity, which is such that the ordinary layman would understand its working and thus be satisfied that he was not being deceived with elaborate instruments which he cannot manipulate. Suppose, for example, that a consumer has a proposition for improving his illumination. With such an instrument he can measure his present illumination at any given number of points, and likewise the illumination by any other system, and at least know whether he is getting more or less. He could even keep the "standard" lamp in his possession until the measurements had been finished, if he wished to be absolutely sure that no tampering of results was possible.

A KEROSENE-OIL LAMP

From *The Scientific American.*

Experiments with a new lighting system have been carried out in Scotland, in which kerosene oil is used. The oil is stored in a tank, which is accommodated in the base of the standard carrying the lamp. In the top of this reservoir is a cylinder filled with compressed carbonic-acid gas, with a small oil container at the bottom holding from one-half to two gallons of oil, which automatically flows thereto from the larger receptacle. A reducing valve connects the oil container with the carbonic-acid gas cylinder, and a fine tube leads to the burner, which has a vaporizer consisting of a jet and an air-mixing chamber, while the burner is fitted with an incandescent gas mantle. The oil is forced from the oil container to the vaporizer through the fine tube by the pressure of the carbonic-acid gas. On reaching the vaporizer the oil is converted into gas and passes through the flame spreader, where it combines with the air, and thence to the incandescent mantle. The lamp is economical in consumption, a light of 200 candle-power being obtained for 45 hours with a consumption of one gallon of oil, and the light is clear, bright, and of great penetrative power.

A CLEVER AND ORNAMENTAL SWITCH

Turning an electric light on or off at the chandelier is very often annoying, especially for ladies, who find that the key at the lamp socket is just beyond their reach. The key at the socket is often in the way of ornamental holders and also frequently turned in the wrong position to be easy of access. A clever way around these difficulties has been found in the construction of a switch to be made a part of the arm of the chandelier, and placed in the position where the gas cock is usually placed. This is shown in the illustration. This places it in a much more accessible position and leaves the socket free for decoration.

We ascribe beauty to that which has no superfluous parts, which exactly answers its end.—EMERSON.

The Illuminating Engineering Society

RESIDENCE LIGHTING

By Jas. R. Cravath.

Paper read before the Chicago Section, May 7.

It is not possible in the limits of one evening's paper to take up the subject of residence lighting either thoroughly or systematically. The subject has been taken up at some length by Mr. V. R. Lansingh and myself in the columns of the *Electrical World* recently, and I have also taken it up in papers and lectures before several Chicago technical organizations during the past year.

As the object of this paper is to lead to a discussion on some of the common questions which come up in residence lighting, I have thought best to have lantern slides made of a number of interiors and to discuss the lighting arrangements shown in these slides.

Fig. 1* shows a room in a costly residence lighted by a central chandelier and side wall brackets. The room is evidently intended for general living room use. The lamps are electric incandescents placed upright. The placing of electric lights upright is a decidedly wasteful proceeding. It is not to be recommended where economy is any object, since it results in more than half the light being thrown upward. I am not inclined to criticize its use in a costly room of this character, however, since here expense is purely secondary to artistic effect. The result of the arrangement in this case is to place the writing table, which is underneath the chandelier, in the shadow of the heavy parts of the chandelier, but the total light in the room is sufficient to make this negligible. The chandelier was evidently designed to use enclosing globes over the lamps, but these have been omitted and frosted-bulb lamps have been used instead. In my opinion 6-inch ground-glass balls should have been used over these lamps to be in keeping with the heavy chandelier. That, however, is largely a matter of personal taste.

From an engineering standpoint the ground-glass globes would give somewhat bettter diffusion on account of their large diffusing surfaces as compared with the frosted-bulb lamps. Clear bulb lamps inside of such globes would also last probably 40 to 45 per cent. longer before burning out than the frosted-bulb lamps, which is a consideration both from an economical and artistic standpoint, because on a chandelier of such size anything increasing the frequency of lamps burning out is likely to interfere with the general artistic effect. On the other hand, the ground-glass enclosing globes probably absorb a little more light than the frosted-bulbs of the lamps. The loss of light with a frosted enclosing globe would necessarily be greater than with a frosted-bulb lamp if the density of the frosting were the same in both cases, because with the enclosing globe the light must pass through an extra thickness of glass. With the sand blasted enclosing globes commonly used, however, it is not necessary to have the sand blasting as dense or deep as the frosting on the lamp bulb because the globe is so much larger than the lamp bulb. Hence, I do not believe in practice; there is usually a very great difference in the amount of light absorbed by these two methods of diffusion.

From a hygienic and artistic standpoint the lighting of this room should be excellent. Rooms where expense cuts so little figure, however, are the exception rather than the rule.

* Note.—The illustrations referred to have been omitted, as the explanations are so full as to give a clear idea of the points brought out.—Ed.

Fig. 2 shows a very common mistake, namely, that of putting electric light or gas fixtures on both sides of a fireplace. When there is a fire in the fireplace, the people in the room will almost invariably sit facing it. The lights on either side of the fireplace shining directly in their eyes are not only bad from a hygienic standpoint, but help to spoil the cozy and cheerful effect of the fire. To make the fireplace effective in adding to the cheerful appearance of the room, its surroundings should not be flooded with other artificial light. It is furthermore decidedly uncomfortable to sit for some time facing a gas or electric light of this kind which shines directly in the eye. It is just this kind of illumination that ruins eyesight. A Chicago oculist is responsible for the statement that the great array of exposed lights on the arches of the Auditorium Theater in this city has produced such a bad effect on the eyes of those frequently in attendance there, that it has brought him in thousands of dollars' worth of business. We should avoid such eye ruining arrangements in our homes.

Fig. 3 shows a highly decorated room in which the principal lighting is done by incandescent electric lamps in large ground-glass stalactites. The arrangement is excellent as far as the diffusion of the light is concerned, as the glare from the bare lamp filament is much reduced by the large ground-glass stalactites surrounding the lamps. In a case of this kind the use of a very small reflector hanging directly on the lamp bulb will frequently make a decided increase in the illumination in the lower part of the room without noticeably robbing the upper parts of the room and without being apparent through the large outer globe. This is presuming, of course, that the neck of the globe is large enough to admit such a reflector.

Fig. 4 shows a corner of a library in a residence which offers considerable food for reflection. It is worthy of note that a mistake sometimes made in libraries of this sort has not been made here. The mistake I refer to is that of placing bracket fixtures above the shelves. The result of such bracket fixtures would be to throw the shelves and books in comparative darkness. We also note here that the bad arrangement of bracket fixtures on each side of the fireplace has been avoided. The general lighting of the room is by means of gas and electric lamps on a central chandelier. The sources of light are apparently enclosed in etched glass shades. Electric lamps intended for the general lighting of a room and placed on a fixture of this kind should be provided with better means of diffusing and softening the light than an ordinary etched bell shade open at the end which allows the full glare from the lamps to shine in the eyes of persons seated around the room. If such shades are used frosted-bulb lamps should be employed. I am inclined, however, to criticize the whole arrangement shown in this figure, for the reason that it does not seem to meet the ordinary needs in a room of this kind. We see that there is an oil reading lamp on the table under the chandelier. Evidently it is used for ordinary reading, as it is equipped with a useful, rather than a decorative shade. We must, therefore, draw the conclusion that the light from the chandelier is not considered satisfactory for reading by the persons who use the room.

This brings us to the undeniable fact that many people do not consider electric light as good as a kerosene lamp to read by. It is worth while to investigate the reasons for this. I believe one reason is that many have just the arrangement of chandelier shown in this figure. By lighting three 16-candle-power lamps, one can get a fairly satisfactory reading light underneath the chandelier; but as this is a rather expensive way of doing it, the user often begins to cast around for something which will cost him less to operate and buys one of the many ornamental (but not useful) portable electric table lamps now on the market.

After trying this for a while with a 16- or 32-cp electric lamp, he finds the result so poor both in quantity and quality of light, that he goes back to kerosene for reading and finds that a good oil reading lamp, such as shown in this figure, will not only give him more light on his reading page, but that it is better diffused and causes less glare from the paper than the clear bulb incandescent electric lamp on an ornamental portable table lamp. As a matter of fact, a much more satisfactory reading light can be obtained from electricity than from kerosene if only the proper equipment is used.

If I were asked to remodel the lighting of the room shown on this slide, I would first of all point the electric light sockets on the chandelier straight down. I would take off the present glassware and in its place put conical or dome-shaped glass reflectors, which would come well down over the lamps so as to shield them from the eyes of persons seated around the sides of the room. As to the type of glass reflector to be used, I would consult the tastes of the owner as to whether he preferred prismatic, opal or sand-blasted glass. The same general treatment could be used on the gas jets. The results would then be that we would have a brightly lighted area under the chandelier, affording an excellent reading light if only one 16-candle-power lamp were turned on if the reflectors were prismatic or opal. By turning on more lamps, sufficient light would be obtained for the general illumination of the room, and at the same time the depth of the reflectors would prevent glare in the eyes of persons seated around the edges of the room. With a brightly lighted central area and darker corners, the room would have a much more cozy and home-like appearance than with the brightly lighted ceiling and poorly lighted floor in the present arrangement, where a large per cent. of the light is being wasted on the ceilings and high side walls. The problem here is the same as that which comes up in the lighting of the ordinary living room of nearly every small residence.

For this reason I will take the liberty of showing again, here, an arrangement illustrated in a paper of mine before the Western Society of Engineers on October 13, last. (Fig. 5). This is one of the best arrangements I know of for a room where both general lighting and reading must be provided for. Both reading and general lighting are taken care of by a single chandelier. For reading purposes the lamp pointed straight downward on the middle socket, is used. For the general lighting any number of lamps necessary can be placed on the arms. In this case only two are needed. The lamps on the arms here are equipped with Holophane diffusing and directing globes, the idea being that these lamps on the chandelier arms would be used for the general lighting of the room at times when a number of persons would be in the room and nearly all would be sitting facing the chandelier. It is therefore highly important to provide a means for diffusing the light from these lamps so that the light will come from the surface of a large globe rather than from a small intensely bright lamp filament. This is well accomplished both by Holophane and sand-blasted glass. The Holophane globe used here acts somewhat as would a reflector, as it directs more of the light below the horizontal than would naturally fall there. A somewhat similar distribution can be secured, together with good diffusion, by the use of a sand-blasted dome or by certain types of opal bell reflectors with frosted-bulb lamps. The central or reading lamp on this chandelier when equipped with an opal or prismatic glass reflector, gives a well-lighted area under the chandelier within which several persons can read, and the results will be much more satisfactory than with a portable table lamp of equal candle-power. The reason for this is that all reflectors used on portable table lamps throw the

greatest intensity of light on the table, and throw only a small percentage of the maximum intensity in the direction of the reading pages of persons seated around the table. Furthermore, the distance from the portable table lamp to the reading page is usually nearly, if not quite as great as from a reading lamp on a chandelier to the reading page. These statements in regard to reading lights have surprised a great many people because the points are so simple that it is strange they have not been brought out before. It is an example of the profit to be obtained from studying details in this business. Hundreds of such details have gone unheeded in connection with illumination up to the present time.

To demonstrate the above points, I recently made a test with a 16-candle-power lamp placed in a compartment three feet above the floor, which latter we will consider as the reading page or surface to be lighted. In an adjoining compartment was placed a portable table lamp also equipped with a 16-candle-power lamp. The table lamp has a decorated opal dome reflector, such as used on kerosene lamps. This is more efficient than many used commonly on electric portables. The portable lamp throws most of its light on the table immediately around the lamp. The well-lighted area in which one can read is much larger in the case of the lamp in the first compartment, which is in a position corresponding to a lamp on a chandelier. The chandelier lamp further performs the double function of a reading lamp and a lamp for the general illumination of the room, whereas the general illumination of the room with the portable lamp is very small. For those who prefer, when reading, that the ceilings and side walls be in comparative darkness as they are with portable table lamps, it is an easy matter to make a silk or paper shade to go over the reading reflector on the chandelier, or if of opal, to decorate it with paint, to produce this effect.

Fig. 6 shows an artistic dining-room in which an attempt to light the pictures by the use of candelabra lamps on brackets defeats itself, since it is much harder to see a picture with bracket lights so near the picture than if the lights were not there at all. It is similar to trying to light the goods of a store window by means of a row of bare lamps exposed around the window, which we all know defeats its own purpose. The pupil of the eye insists on contracting in self-defence when we put bright lights in the line of vision.

The table is lighted by six lamps placed in art glass spheres high up near the ceiling. This is a good arrangement in a dining-room of this character, where light on the pictures on the side walls is needed. In the majority of dining-rooms more light on the table and less on the side walls would be desirable.

Fig. 7 shows an excellent method of dining-room table lighting by means of an art glass dome suspended by a chain. I show this here to call attention to a mistake frequently made in equipping these art glass domes for table lighting. They should have one lamp in them and that pointed straight down. This can be of any candle-power desired. The reason for using one lamp pointed straight down is that it can be equipped with a glass reflector which will distribute the light evenly over the table with good efficiency. If the reflector is deep enough it will diffuse the light from the lamp. If a deep reflector is not used, the lamp should have a frosted bulb; or a ground-glass bottom should be provided for the art glass dome.

Bedrooms are usually the most unsatisfactorily lighted rooms in the house. The trouble may be with the original design of the lighting (it usually is), or it may be that furniture has been shifted in some unexpected way so as to defeat the original purposes. An example of this is shown in Fig. 8. Here the bed has been placed between the bracket lights in the position evidently originally intended for the chiffonier or dresser, and this in

spite of the fact that one would reasonably expect the dresser to be placed near the washstand rather than with the bed between it and the washstand.

The most satisfactory method of lighting a mirror of any kind is to place a light on each side of it, as shown in Fig. 9. The dressing table shown in this slide is excellently arranged, the only criticism being that frosted-bulb lamps should be used in these open bell shades to avoid the glare from the lamp filament. In lighting a mirror for shaving purposes the lamps on the brackets should ordinarily be about 4½ feet above the floor. This is the lamp height—not the outlet height. Lights so low, however, do not light the top of the head. To provide for this the ideally-lighted bedroom dresser should have a light either on a bracket or on a pendant above the mirror. Where the expense of three outlets for one dresser may be objected to by the owner, this light over the mirror can be dispensed with if there is a light in the center of the room well up toward the ceiling. If the only lights in the room are the bracket lights each side of the dresser, they should be placed about 5 feet 6 inches to 5 feet 9 inches above the floor, which is a compromise between a light at the best height for shaving and a light for hair dressing. There is a number of schemes which can be used to provide portable bracket and dresser lights, to be plunged into one central outlet where only one outlet in a bedroom is provided, but to discuss these here would take up too much time.

Fig. 10 shows an attempt to light a porch which reminds one of the Dark Ages. On each side of the entrance is a lantern with clear glass containing an incandescent lamp. The crude blinding effect of these lanterns is only exceeded by the platform lighting at some of our steam railroad way-stations, where a kerosene lamp backed with a powerful mirror reflector throws its rays directly in the eyes and blinds everyone walking its way.

Before closing, I want to say a word about the much-neglected kitchen light. The owner of a house having spent all the money he thinks he should for fixtures and glassware in the other rooms of the house, is frequently content to let the kitchen go with a bare gas or electric drop light about 6 feet above the floor in the middle of the room. In the case of gas a Holophane shade or opal dome reflector will improve conditions somewhat. If the lamp is electric, it should be placed at the ceiling and equipped with a reflector which will throw the maximum light toward the sink and range. For most kitchens this reflector will be a fluted opal cone or an opal dome or the proper shaped prismatic reflector. In new kitchens a bracket light near the sink should be provided wherever possible, and it is also well to have one near the range. Such bracket lights should have reflectors for throwing the light down where it is wanted, and also since they are low, the reflector shades the light so that the eye is not blinded by the glare from the bare lamp filament.

I have only touched on a few points which come up in residence lighting, but trust that they will open up a profitable discussion.

Papers Read Before Technical Societies

PRINCIPLES OF ILLUMINATION FROM THE STANDPOINT OF THE GAS ENGINEER

By Van Rensselaer Lansingh.

Presented at the meeting of the Western Gas Association, Cleveland, O., May 16.

Introduction.—Until the last few years, and even to-day, in some cases, the question of illumination has not been recognized as being of any special interest or concern of the gas engineer. His business has been to supply gas to the consumer, leaving it to the latter to obtain whatever benefit he could thereby. In other words, the gas man, like the electric man, has sold cubic feet of gas or in the case of the electric man, kilowatts and not illumination.

Owing to the stimulating effect of electric competition, this attitude of the practical gas man has been gradually altered, until to-day most gas companies endeavor to help the customer obtain the maximum light from the gas he uses, generally by encouraging the use of some form of mantle burner.

The next step is naturally to assist the customer to obtain, not only the maximum light from the gas he uses, but the best illumination; that is, assist him in getting the illumination he desires, which means the ability to see things comfortably and economically. While the customer actually pays the gas company for cubic feet of gas used, it is simply a means to an end, that end being the ability to see well, and the present spirit of co-operation between producer and user, now so manifest in the gas world, is bound to produce, in the long run, the best results for the gas company in dollars and cents.

Illumination, or the effect obtained by light, is not purely an engineering problem requiring only technical knowledge, but it also embraces thorough practical knowledge and experience, as well as a sense of the artistic. It does, however, present so many problems requiring special study, engineering knowledge and technical skill, that the illuminating engineer is, to-day, at least in the electrical field, of recognized standing. The object of this paper, therefore, is to point out some of the fundamental principals necessary to such a knowledge and the application of the same to every-day problems of lighting.

The writer has undertaken to state at the outset some of the primary principles of light and its measurement, which to those well familiar with the subject may be passed over. He has found, however, among practical gas men, men familiar with light sources and with the term candle power as ordinarily used, such a lack of knowledge of the general subject that he deems it wise to present here, in more or less detail, some of the underlying principles necessary to the correct understanding of good illumination.

LAWS OF LIGHT.

Light is ordinarily measured in terms of candle power, the unit being the light given on the horizontal from a standard candle burning at a given rate. It is customary to measure most forms of illuminants by the light given on the horizontal, as they generally give their maximum light in that direction, but in order to correctly judge of the efficiency of a source of light (by efficiency is meant the ratio of the total flux of light to the energy consumed) we must take into account not only the maximum light, but also the light given in other directions; that is, the mean spherical candle power. In other words, if the source of light in question gives the same total amount of light, but equally in all directions, we would term this the mean spherical candle power. As long as sources of of light were of the same shape and size, it was sufficient to compare their mean horizontal candle power, but with sources differing as they do to-day in both respects, we must judge of their relative efficiencies by the total amount of light and not by the amount given in any one direction. This sounds like a truism, but from some of the advertising of some of the manufacturers in regard to candle power, where the light in given directions is added together to give the rated candle power, it would appear necessary to call attention to such errors.

Such measurements of light are made on a photometer, which is an instrument simple in theory but involving many factors in actual practice. The length of this paper precludes a discussion of photometry, but the fundamental principles of the same will be briefly described.

All photometers are based on the law of inverse squares which states that light varies inversely with the square of the distance. Fig. 1 illustrates this graphically. It is evident from an inspection of this that a surface, C, twice the distance of B from the source of light, will have only one-fourth the light falling on each point and that D will only have one-ninth, since the area illuminated in both cases by the same rays are, respectively, four and nine times that of B.

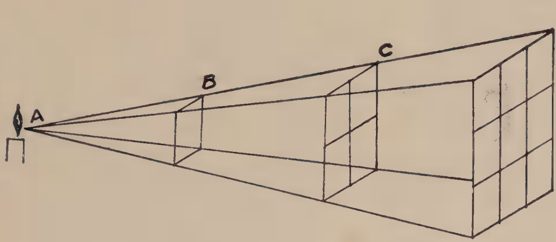

FIG. 1
Illustrating the Law of Inverse Squares.

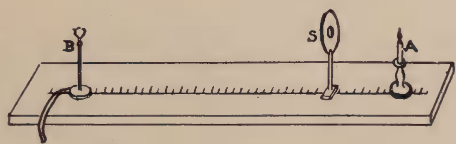

FIG. 2
Showing Principle of Photometer.

Fig. 2 shows a Bunsen photometer diagrammatically. Briefly, it consists of a standard source of light A, the source of light to be measured B, and a screen S, which is composed of three layers of paper, the center one being thin, like tissue paper, while the two outer ones are heavier, having a central opening, either round or star shaped. When seen by reflected light the center will appear darker than the outside, since part of the light is transmitted and therefore less reflected. If viewed by transmitted light, i. e., light from the opposite side, the center will appear lighter than the outside, which does not allow the light to pass through. In operation the screen is moved back and forth until the center spot is equally bright with the outside portion. By means of two mirrors placed at an angle, both sides of the screen can be seen at the same time, and when they are equally bright the two lights are inversely proportional to the square of the distances from the screen. Thus, if the distance from A to S is 1 foot and from B to S 4 feet, light B will be sixteen times the strength of light **A**.

This would measure only the horizontal candle-power. To get the candle-power at other angles, the light B could be tipped, but in the case of gas measurements this is undesirable, as generally lights are made to burn in a vertical position, so that in actual practice a series of mirrors are used, which reflect the light at different angles into the photometer without necessitating the movement of the source of light. Fig. 3 shows a cut of the photometer used for testing gas lights by the Electrical Testing Laboratories.

This device consists primarily of three mirrors, each 22 by 31 inches, by means of which the light from the source to be measured may be thrown upon the photometer. It is always incident upon the photometer at normal, irrespective of the angle at which it emanates from the source. The mirrors are supported by a strong framework of iron, which can be rotated upon a horizontal axis, the prolongation of which passes through the source of light and the photometer. The mirrors are placed in position so as to receive the light at the desired angle in the vertical plane, and are clamped in such position. They are rotated easily being balanced by the weight E. In the illustration a ceiling fan electric motor is shown for the purpose of rotating an electric lamp. It can be replaced by a gas

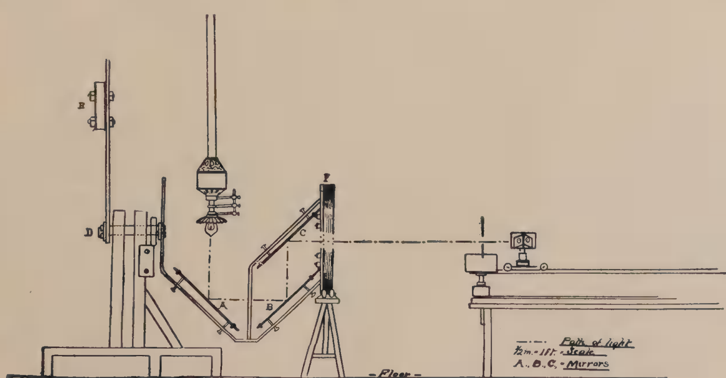

FIG. 3.—MIRROR REFLECTOR PHOTOMETER—SCALE ABOUT 1 TO 64.

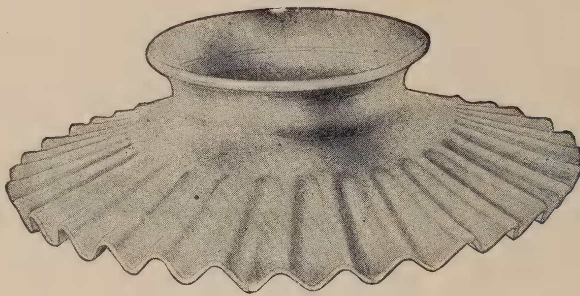

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

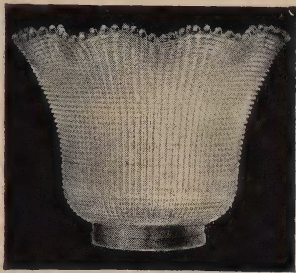

Fig. 10.

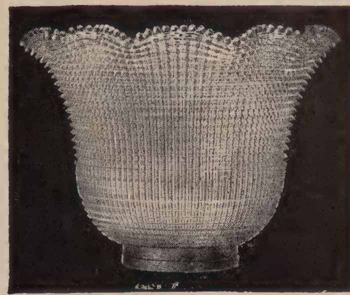

Fig. 11.

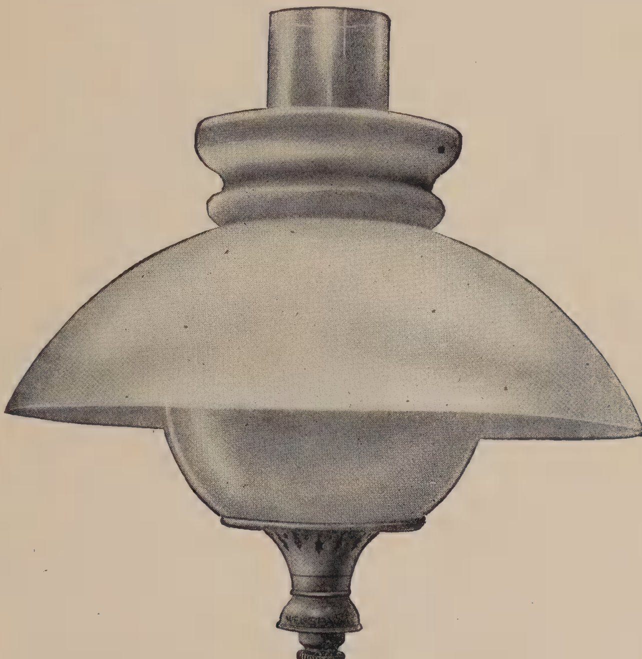

Fig. 12.

Fig 17.

Fig. 18.

fixture. With this device, sources of light not exceeding 18 inches in diameter can be measured successfully.

It should be borne in mind that a photometer measures not only the intensity of light but also the quantity (by intensity is meant the candle power per square inch of illuminating surface), and that in comparing different sources of light it is necessary to take both these factors into account. For example, the intensity of the filament of a 16 candle power, 3.1 watt incandescent electric lamp is approximately 500 candle power per square inch, which is 16 times as great as that of a mantle burner giving 30 candle power per square inch, although on account of the area of the mantle the quantity of light given by the latter is much greater. Both of these factors must be borne in mind when considering the effect on the eye of any source of light.

ILLUMINATION.

The difference between light and illumination should be carefully noted. Light is a cause; illumination an effect. An object on which light falls becomes illuminated. Illumination, therefore, is the result produced by light. An object is well illuminated when it can be easily seen without fatigue or strain on the eyes. Good illumination, therefore, requires several things, among which may be mentioned:

1. Sufficient light to enable one to see clearly and distinctly.
2. Avoidance of too much light, which produces a blinding and fatiguing effect on the eye.
3. Avoidance of having a bright light in the field of vision, which cuts down the ability to see clearly things which are less brilliantly illuminated.
4. Avoidance of streaks or striations, which, however, are more noticeable with electric than with gas lights.
5. A steady light, i. e., avoidance of a flickering light, like an open flame burner with insufficient draft, which quickly tires even the strongest of eyes.
6. Avoidance of regular reflection, which is commonly known as glare, due to the light striking an object at such an angle that a large part of the light is reflected directly into the eyes.
7. Avoidance of two sharp contrasts, such as, for example, a brilliantly lighted desk with the rest of the room in darkness.

From the foregoing it will be seen that, in considering any form of illumination, it is absolutely necessary to take into consideration the effect on the eye. Nature has given us in the eye a wonderful and delicate camera, which with proper care can be used indefinitely, but which, with the introduction of lights of high intrinsic brilliancy, we have shamefully misused. Witness today the percentage of people wearing glasses in this country compared with twenty-five years ago, and especially note the report of our oculists on the rapid increase of glasses among children, and it will be self-evident that, unless proper care is taken of the eyes, we shall soon be compelled to resort to the oculists to overcome the defects due almost wholly to bad lighting. One oculist in Chicago states that the lighting of the magnificent Auditorium, with its rows of bare incandescent lamps, has brought him in thousands of dollars' worth of business. With these facts in mind, do we not owe not only to ourselves, but to the public in general, to do what we can to overcome such conditions?

We thus see that in dealing with modern sources of light it is necessary to take into account the effect of the same on the eye, and in every case reduce the intrinsic brilliancy as far as possible. With electric incandescent lamps it is possible sometimes to conceal them entirely from view, thus getting indirect illumination, which is generally satisfactory except from the standpoint of economy. With gas such treatment is usually out of the question, although not always so, and we should therefore place our lights high enough to be out of the field of vision wherever possible, and to use diffusing globes, which not only cut down the intrinsic brilliancy, and therefore make it possible to see with much more comfort, but actually enable us to see more clearly, owing to the eye being enabled to work with a wider aperture. It is therefore necessary to study the effects, not of the lights alone, but with the glassware which it is desired to use. The absorption or loss of light due to the surrounding globes, as well as their distribution, must be considered. Such figures will be given later in the paper.

PHOTOMETRIC CURVES.*

Upright Mantle Burners.—We have already seen that sources of light do not give the same candle-power in all directions. Thus, in the case of a bare mantle burner, the photometric curve of which is shown in Fig. IV., we have 83 candle-power on the horizontal, but directly underneath practically none, owing to the shadow cast by the burner. If we measure the candle power of the light as seen from different angles and represent the intensity at these different angles by the distance from a fixed point, we have what is known as a photometric curve. By such a curve we can at once obtain the intensity or candle power at any given angle, by simply

* All of the tests here given, with two exceptions, were made by the Electrical Testing Laboratories, so as to have comparable results from an unbiased source. The different curves are not comparable as to absolute values, unless so specifically stated, but only as to their relative distribution, inasmuch as the tests were made on different burners with different lengths and styles of chimneys and therefore under different conditions.

measuring the distance from the center to where the curve is cut by the line. Thus in Fig. IV. we have 30 candle-power at 60° and 77 candle-power at 15° below the horizontal. It should also be noticed that 55% of the light goes above the horizontal and only 45% below, which means, as lights are practically always placed above the level of the eyes, that, unless some means be taken to throw this downward, one-half of the light is wasted, except for the indirect reflection of ceiling and high side walls. Fig. V. shows the curve of the same burner equipped with a small fluted porcelain shade.

While such a shade does not hide the bare mantle and therefore does not aid in the diffusion, it does give an increase of light at all angles below the horizontal, and as such is to be preferred to the bare mantle.

Fix. 6 shows the curve of the common six air-hole opal Q globe, burning 5.1 cubic feet of gas per hour at 1.5 inches pressure. Inasmuch as its intensity is less than the bare mantle, it is to be preferred to the small flat fluted porcelain shade, although its efficiency is much less. In all comparisons we must bear in mind both diffusion and distribution, and, inasmuch as it is seldom that we get both factors in one globe, we must select that which is most necessary for the case in hand.

Fig. 7 shows the curve of the ordinary ground glass, tulip shaped globe. This globe simply diffuses and softens the light without materially altering the distribution. Its absorption is over 25 per cent.

Fig. 8 shows the curve of a fancy tulip globe, with dark mottling and stripes. Its absorption is over 50 per cent. Such globes give very artistic results, good diffusion, and, where economy is no object and a sufficient number can be used to get the required illumination, they are to be highly recommended.

Fig. 9 shows the curve of what is known as a Class A Holophane globe, shown in Fig. 9A, designed to throw the light directly downward, such as for use over dining room and library tables. It gives a remarkable amount of light downward, but of course at the expense of the light at other angles. Its absorption is about 18 per cent. The diffusion obtained by such globes is about equal to that of opal, without, however, the large absorption, inasmuch as the globes are made of perfectly clear glass and depend upon their accurate design for their diffusing and redirecting qualities. Such globes, owing to their prismatic faces, are apt to collect the dust, and should therefore be kept clean. The dust, however, affects their appearance more than their efficiency, the additional absorption of a dusty globe being about 13 per cent. They should never be used in places where the air is greasy, such as over stoves, as the grease is apt to settle on the prisms, and is extremely difficult to remove. When such globes, however, are used intelligently they form an important adjunct to the illuminating engineer's work, as they combine both qualities of diffusion and redirecting powers with small absorption.

Fig. 10 shows the curve of what is known as a Class B Holophane globe, shown in Fig. 10A, designed to give a general distribution rather than special. Its absorption is about 12 per cent.

Fig. 11 shows the rather remarkable curve of what is known as a Class C Holophane globe, designed to throw the light sideways just below the horizontal, in order to cover a wide area. The tests show an absorption of only 6 per cent., which is probably too low.

It will be noted by a comparison with the curve of the bare mantle shown by the dotted line, that there is actually an increase on the horizontal, where the bare light is a maximum, and a considerable increase to as far as 30° below. As these angles are the critical ones in street lighting, the writer ventures the opinion that, if such a globe were properly protected from the rain and dust by enclosing it in the ordinary street post lantern, it would increase the lighting of our streets in two ways. First, by an actual increase of the light falling on the streets, and, second, because of its diffusing qualities it would enable a pedestrian to see more clearly, owing to the fact that the eye, not being blinded by an intense light, could work with a larger aperture, and therefore see more clearly and distinctly.

Fig. 12 shows the curve of an opal dome and opal bobesche. Such a combination is good for reading when the light is directly above the work. A bobesche should always be used with a dome shade whenever there is a possibility of the eye being able to see the mantle. As a matter of fact, bobesches should be made about half an inch deeper, as at present most of them do not come high enough to cut out all view of the bare mantle.

Fig. 13 shows the curve of a similar green dome shade and opal bobesche. This makes a splendid reading light if directly above the work, but concentrates it too much if used on a low portable, with the reader sitting alongside the table. A green dome with green bobesche is practically out of the question, owing to the large absorption of the cup. Such a combination depends almost entirely on the reflection from the white lining of the green dome and is very inefficient.

Fig. 14 shows the curve of a green dome and Class A Holophane bobesche.

This bobesche, being higher, cuts off all view of the mantle and gives a strong light at all angles. A comparison of this with Figs. 12 and 13 is instructive, and shows

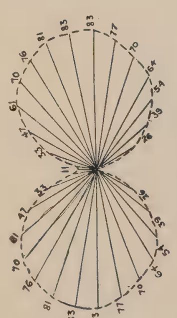

FIG. 4
Curve of Bare Incandescent Lamp.
Mantle Burner

FIG. 5
Curve of Fluted Porcelain Shade over
Mantle Burner

FIG. 6
Curve of Opal Q. Chimney.
Mantle Burner

FIG. 7
Curve of Ground Glass Globe
Mantle Burner

FIG. 8
Curve of Fancy Opal Globe
Mantle Burner

FIG. 9
urve of Holophane Class A Globe
Mantle Burner

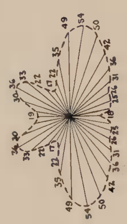

FIG. 10
Curve of Holophane Class B Globe
Mantle Burner

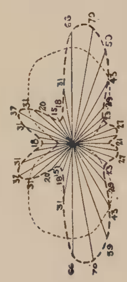

FIG. 11
--- Curve of Holophane Class C Globe
...... Curve of Mantle Burner. Bare

FIG. 12
Curve of Opal Dome & Opal Bobesche
Mantle Burner.

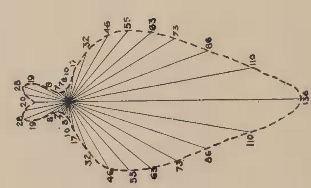

FIG. 13
Curve of Green Dome & Opal Beobesche
Mantle Burner

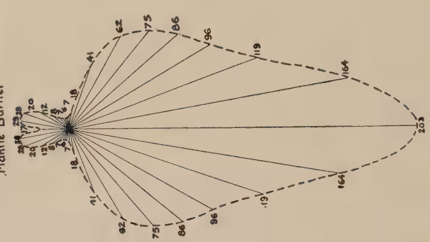

FIG. 14
Curve of Green Dome & Holophane Beobesche
Mantle Burner

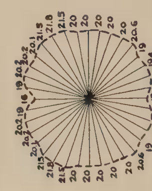

FIG. 15
Curve of Open Gas Horizontal Distribution

FIG. 16

Curve of Open Gas Vertical Distribution

FIG. 17

Open Gas Etched Globe

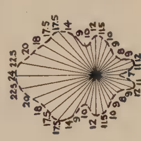

FIG. 18.

Curve of Open Gas Pressed Glass Globe

FIG. 19

Curve of Open Gas Holophane Class A Globe

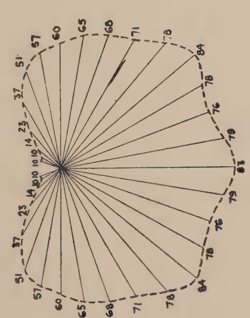

FIG. 20

Curve of Bare Inverted Burner

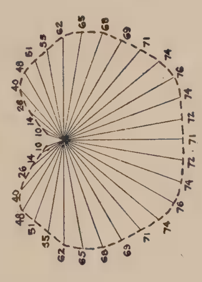

FIG 21

Curve of Inverted Burner with Opal Globe.

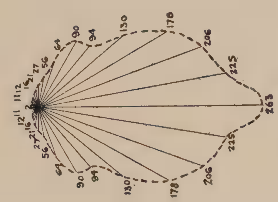

FIG. 22.

Curve of Inverted Burner with Pagoda Reflector

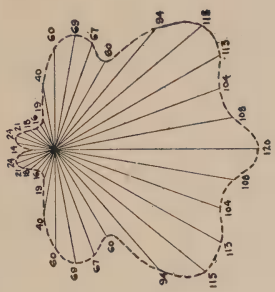

FIG. 23

Curve of Inverted Burner with Holophane Globe

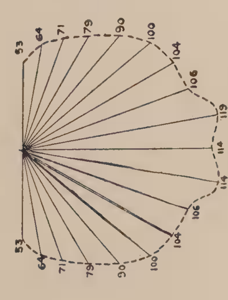

FIG. 24

Curve of Inverted Burner with Flat Porcelain Reflector

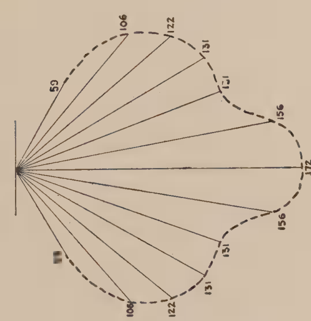

FIG. 25

Curve of Inverted Burner with 8 inch Deep Cone Reflector.

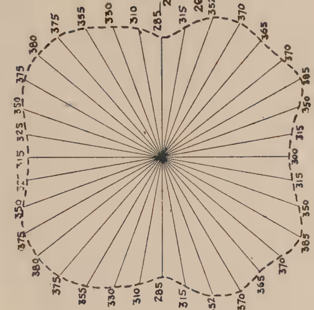

FIG. 26

Gas Arc No. 1

Curve of Horizontal Distribution

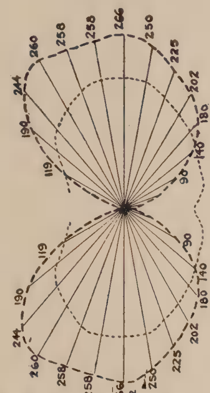

FIG. 28

Curves of Gas Arc No. 2

--- Clear Globe, No Reflector

...... Alabaster Globe, No Reflector

how easily illumination may be improved by slight changes.

OPEN FLAT GAS FLAME BURNER CURVES.

In considering the distribution of light from a mantle burner we have assumed that it was symmetrical on the horizontal, i. e., if we looked at the light from one side or the opposite side it was the same. This is so nearly true that it can be safely assumed.

Fig. 15 shows the distribution curve in a horizontal plane of a flat flame burner showing that when viewed at right angles to the plane of the flame, the candle power is slightly greater than when viewed end on, due to the fact that the hot particles of carbon slightly shade the light from the other parts of the flame. It is not as great, however, as one would suppose and shows that, generally speaking, it is immaterial at what angle the tip of the burner is placed.

Fig. 16 shows the vertical distribution of an unshaded open gas burner taken at right angles to the plane of the flame. It will be noticed that the curve of the light is remarkably uniform with the exception of directly underneath where a small shadow is made by the pillar and the tip. Also, as in the case of the mantle burner, practically one-half of the light is above and one-half below the horizontal.

Fig. 17 shows the distribution curve of an etched glass globe, representing perhaps the great majority of open flame globes. It should be noticed that there is comparatively small absorption, viz., about 14 per cent., but that a large amount of the light is thrown upward, the globe acting somewhat as a reflector, there being a diminution of 30 per cent. below the horizontal.

The real efficiency of a globe should not be measured, generally speaking, by the amount of light it gives forth, but rather by the amount of light which it throws below the horizontal, or in some particular direction where the light is wanted. Thus in the case of the globe shown in Fig. 17, although its absorption is comparatively small, the loss of light below the horizontal is rather large, and as this is the light which is generally used, we see that in our efforts to obtain an artistic effect and at the same time shield the eyes, we do so at a considerable loss.

It should also be noted that in the case of open flame burners, the necessity for diffusion is not nearly as great as with mantle burners, as both the intensity and quantity of light are low.

Fig. 18 shows the curve of a beaded and ribbed globe. The absorption of this globe is low, as it is made of perfectly clear glass, but it also has the same tendency as all such globes, to act slightly as a reflector and throws much more light above than below the horizontal.

Fig. 19 shows a Class A Holophane globe designed to diffuse the light and at the same time throw a strong light downward. Its absorption is about the same as the other open gas globes, but its distribution curve is entirely different.

INVERTED BURNERS.

In studying the distribution of light from an inverted burner, the first thing one notices is the marked difference between it and the upright burner. Thus, in the case of the bare upright mantle bureau we have 55 per cent. of the light above the horizontal and 45 per cent. below, while in the case of the inverted burner we have only 33 per cent. above the horizontal and 67 per cent. below. From this we would naturally draw two conclusions:

1. As lights will, in general, be placed on present chandeliers, they will be lower, and, therefore, the necessity for a diffusing globe will be greater, especially as the temperature of the mantle is higher and of greater intrinsic brilliancy.

2. The necessity for redirecting the rays below the horizontal will not be as great as formerly.

A corollary which naturally follows, is that a greater variety of globes or shades will be permissible, inasmuch as the tendency of any open form of shade will be to throw the light downward, whereas with upright burners we have the exact opposite.

Fig. 20 shows the curve of an inverted burner with a small, clear chimney, but no outer globe. This gives a mean spherical candle power of 54, with a consumption of 3 cubic feet of gas per hour, or 18 mean spherical candle power per cubic foot of gas. Comparing this with the standard upright mantle burner, not of the air hole pattern, we find that the efficiency of the two are practically the same, as the test shown in Fig. 4 gives a mean spherical candle power of 63, with a consumption of 3.7 cubic feet of gas per hour, or 17 mean spherical candle power per cubic foot of gas.

Fig. 21 shows the curve of a dense opal globe on an inverted burner consuming 3.85 cubic feet of gas per hour. The mean spherical candle power of this combination was 55.7 or 14.5 candle power per cubic foot of gas. This should be compared with Fig. 6, which is an upright air-hole burner with an opal chimney, burning 5.1 cubic feet of gas per hour; as the mean spherical candle power of this is 45.8, we have only 9 candle power per cubic foot of gas, so that the upright air-hole style is extremely inefficient when compared with either the inverted or standard upright type of burner.

Fig. 22 shows the photometric curve of the same burner used in Fig. 20, equipped with a pagoda reflector. It will be noted

that this gives an extremely downward light, but at the same time throws a good light to the sides. There is an increase in illumination at all angles below 30° from the horizontal.

Fig. 23 shows the same burner as is used in Fig. 20, equipped with a holophane diffusing globe, showing that it is possible to obtain good diffusion with a practical increase of light at all angles below the horizontal.

Fig. 24 shows the same burner as shown in Fig. 20, equipped with a flat porcelain reflector. It will be noted that in Figs. 24 and 25 the curves are not carried above the horizontal. Both of these tests are due to the courtesy of the manufacturers, all the other tests having been made by the Electrical Testing Laboratories.

Fig. 25 shows the curve of the same burner with an 8-inch deep cone reflector. This should be compared with Fig. 22. It should be noted that the two are not drawn to the same scale.

GAS ARCS.

The length of this paper precludes much of a discussion as to the relative merits of cluster gas arcs as compared with individual mantle burners, either upright or inverted.

It should be noted, however, that a four mantle gas arc does not give as high an efficiency, with respect to its total flux of light, as four individual burners. Thus in the case of the standard upright burner consuming 3.7 cubic feet of gas per hour, shown in Fig. 4, we have 63 mean spherical candle power or 17 candle power per cubic foot of gas. The mean spherical candle power of the most efficient type of four mantle gas arc, burning 21 cubic feet of gas per hour, is about 250, of 12 candle power per cubic foot. This means a reduction of nearly 30 per cent.

The reason for this will be seen at once when we note that the mantles largely shade each other, thereby lowering the total efficiency, although each mantle gives more light than the individual burner.

Outside of the question of efficiency, it can also be said that, in general, better distribution of light can be obtained from small units properly placed and with the right shades than with large ones. For the above reasons it does not seem wise to advocate of the gas arc, except in special cases and under certain conditions.

As far as the writer knows, little, if any, reliable data has been published on gas arcs, with respect to their distribution, their relative efficiency as compared with individual burners, etc., consequently two of the best known types were selected for test.

Fig. 26 shows the distribution in a horizontal plane of gas arc No. 1 (the Welsbach). It should be noticed that the distribution is unsymmetrical, there being a difference of over 35 per cent. between the maximum and the minimum. In one position only two mantles are visible, while by shifting the point of view 30° three of the mantles are entirely visible and the fourth partly so.

We should, therefore, note that in installing such arcs they should be placed so as to secure their maximum candle power in the proper direction, a point of considerable practical use, but seldom taken advantage of, as it is thus possible to materially increase the illumination in given directions without any additional cost.

TABLE I.

	Clear Globe with Porcelain Refl. First Plane.	Clear Globe with Porcelain Refl. Second Plane.	Alabaster Globe Second Plane.
Pressure	1.5	1.5	1.5
Consumption	21.0	21.0	22.5
Indicated Mean Spherical Candle Power	230.0	267.0	245.0
Indicated Mean Lower Hemispherical Candle Power....	281.0	345.0	240.0
Mean Spherical Candle Power per Cubic Foot.	11.0	12.7	10.9
Mean Lower Hemispherical Candle Power per Cubic Foot	13.4	16.4	10.7

Fig. 27 shows two photometric curves, in a vertical plane, of the same lamp, the dash line representing it equipped with a clear globe and flat porcelain reflector, while the dotted line represents it equipped with alabaster globe without reflector. It will be noted that, except directly underneath, there is a material increase in the useful light

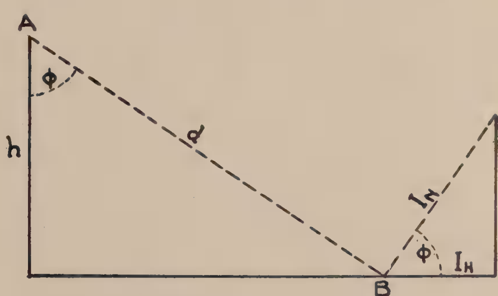

FIG. 29.

due to the use of the clear globe and reflector, but, on account of the diffusion obtained by the alabaster globe, it is, generally speaking, better to sacrifice the in-

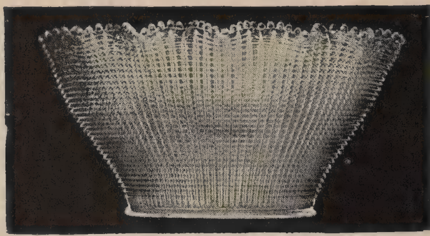

Fig. 19

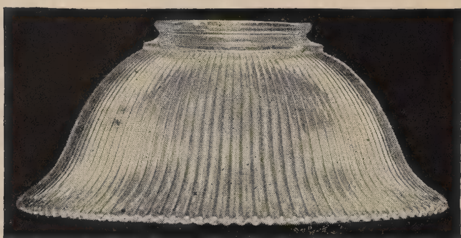

Fig. 22

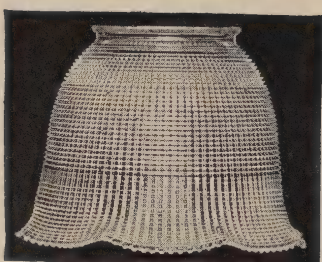

Fig. 23

Fig. 26

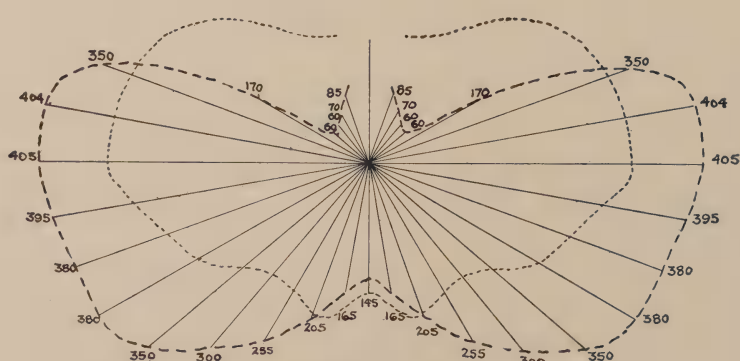

FIG. 27

Curves of Gas Arc No. 1

– – – Clear Globe, with Reflector.

.... Alabaster Globe, No Reflector.

FIG. 30.—THREE-LIGHT CHANDELIER AND TWO BRACKETS.

crease of light, whenever the mantles are apt to fall directly in the line of vision.

Tests were made in two vertical planes, the first, normal to the common vertical plane of two adjacent mantles. In this case only two mantles were visible. The second vertical plane investigated was 45° removed from the first. In this plane three mantles were visible. The indicated mean spherical candle power and the indicated mean lower hemispherical candle power values are computed from the intensities determined by measurements in a certain vertical plane. As the distribution of light in the horizontal plane about the lamp is non-uniform, neither of the values given represents the true mean spherical candle power, which will lie somewhere between them. This can be verified at once by reference to the horizontal distribution curve. The results of the tests on this arc are as shown in Table I.

Fig. 28 shows the vertical distribution curve of gas arc No. 2 (the Humphrey), the dash line being the test with clear glass globe in the second plane and the dotted line the test with an alabaster globe in the third plane. No reflectors were used.

With this arc tests were made in three vertical planes, the third being halfway between the first two mentioned in the case of gas arc No. 1. In the third plane it is possible to see part of the fourth mantle.

The remarks with reference to the mean spherical candle power values of gas arc No. 1 apply also to this test. The results are as follows:

	Clear Globe, without Reflector. First Plane.	Clear Globe, without Reflector. Second Plane.	Alabaster Globe. Third Plane.
Pressure	1.6	1.6	1.6
Consumption	18.0	18.0	19.0
Indicated Mean Spherical Candle Power	177.0	200.0	162.0
Indicated Mean Lower Hemispherical Candle Power	168.0	185.0	166.0
Mean Spherical Candle Power per Cubic Foot.	9.8	11.1	8.5
Mean Lower Hemispherical Candle Power per Cubic Foot	9.3	10.3	8.7

DISTRIBUTION.

Having given the photometric curves, it is possible to calculate the illumination in any part of a room we desire to light.

The unit of illumination is one-foot candle. This can be defined as follows: If we had as a source of light, one standard candle, and held the object to be illuminated on a horizontal plane at a distance of one foot, the illumination on the subject would

FIG. 31.—LIGHTING WITH CLEAR GLOBES AND REFLECTORS.

FIG. 32.—LIGHTING WITH ORNAMENTAL GLOBES.

FIG. 33.—GOOD EXAMPLE OF GAS ARC STORE LIGHTING.

FIG. 34.—OPAL GLOBE FOR GAS ARC STORE LIGHTING.

be one foot-candle. If the light were of 16 candle power and we held the object to be illuminated four feet away we would again have one foot-candle, inasmuch as the light varies inversely as the square of the distance. In order, therefore, to determine the illumination of any object, we simply have to divide the candle power of the source of light, when viewed from the point in question, by the square of the distance from the light to the point. Thus, in Fig. 29, if A is the source of light, B, the point at which we wish to determine the illumination, C P, the candle power of the light at the angle ϕ and d the distance from A to B, we will have an illumination

$$I_N = \frac{C\ P}{d^2}$$

This gives what is known as the normal illumination, which is the effect we get when the rays of light strike perpendicularly to the object, that is to say, on a plane at right angles to A B. Thus, if we are reading in a church we would naturally tip our book to such an angle, as to have the rays of light perpendicular, in order to obtain the maximum illumination. If, however, we should place our book flat and the light were not directly above it, we would not get as strong an illumination as before, and we should have to take into account the obliquity at which the rays of light strike the object. In this case we would have

$$I_H = \frac{C\ P}{d^2} \operatorname{Cos}\phi$$

where I_H is the horizontal illumination and Cos φ the multiplying factor to change from normal to horizontal illumination.

A more complete discussion of this subject cannot be entered into here, but for those who wish to pursue the subject further, reference is made to a paper by the writer before the Western Society of Engineers in April, 1903. It is sufficient to state that quite accurate results can be obtained by carefully designing the illumination of any given room, and that these results can be predetermined, so that before the installation is made, it will be possible to locate the lights so as to get very closely the desired illumination, although on account of the various variable conditions with gas burners it is not possible to determine results as accurately as with incandescent electric lights. As an example may be mentioned the illumination of a church designed by Prof. William Lincoln Smith. Calculations were first made and after the installation was completed, the illumination was measured with an illuminometer. The mean of over 80 readings showed a variation of a little over 6 per cent. from the calculated illumination, which means that, when the color scheme of a room is carefully considered, and the candle power and distribution curves of the sources of light are known, it is possible to design the illumination of a given room with about as much accuracy as enters into many problems of engineering work.

EXAMPLES.

A number of photographs of different installations of gas, both good and bad, are here given. These illustrations are selected from different types of subjects, so as to bring out the practical application of the foregoing principles in different classes of work.

Fig. 30 shows an ordinary bedroom with a three light chandelier, a side bracket next to the dresser and a bracket with a mantle burner in the corner. This seems to be a well lighted room. The chandelier gives good general illumination and the bracket next the dresser is placed at the proper height to throw light on the person standing in front of the mirror. It would hardly be advisable to use a mantle burner on this bracket, unless a dense diffusing globe were used. The mantle burner in the corner, which is used for reading, is well placed and well equipped, except that a bobesche might be used to good advantage. This is not necessary, however, in case the person sits with his back to the light or the light is directly above the table as in this instance.

I have in mind also a well lighted dining room. The center arrangement, which can be pulled up and down, is equipped with an argand burner, giving a soft, mellow light, while the opal dome acts as a good reflector. The other lights on the chandelier can be used when necessary for general illumination of the room. The argand burner might be equipped with an opal or holophane bobesche to good advantage so as to protect the eyes. It should be noticed in such cases that where a center light is used, as well as other lights, it is not desirable to mix the color effects of mantle burners with open gas. The argand burner, having practically the same color as an open flame, should be used in preference.

A certain church has bare gas brackets along the side walls and clusters of open flame burners over the organ and the choir. This is a good example of what to avoid as far as the lighting of the front of the church is concerned. The lights there are placed directly where everybody must look at them during the entire length of the service. They are so situated as to be not only tiring to the eye, but, owing to the eye working with a small aperture, the ability to see the preacher is materially decreased. A canvass among the congregation would doubtless disclose the fact that many people were subject to headache when in the church, and that, owing to the fact that it would be easier to close the eyes than to look at the lights, people were put to sleep, not necessarily by the sermon.

FIG. 35.—HOW NOT TO DO IT.

Fig. 31 shows a millinery store equipped with bare mantle burners. The distribution of light is good, as will be seen by referring to the distribution curve of this combination shown in Fig. 5, but the glare is inexcusable. This should be compared with Fig. 32, where the distribution is not as good as in the former case, but where, owing to the dense globes used, we have nearly perfect diffusion and a light which is soft and easy to see by. It is much preferable to Fig. 31.

Fig. 33 shows a small store lighted by a gas arc. It will be seen that the distribution of light in this case is fairly good, and that the light is placed so high as to be, generally speaking, out of range of the eye. This is a good example of how a gas arc can be used to advantage.

Fig. 34 shows a hat store lighted with gas arcs equipped with alabaster globes. In a store of this length, where the arcs are placed low, the use of alabaster globes is to be highly commended. This is another example of where gas arcs are used effectively. Attention is called to the fact that an examination of this store will show that gas arcs, electric arcs and electric incandescent lamps are used. This is highly reprehensible if they are lighted at the same time. We should be very careful at all times never to mix our color effects. Nothing in the lighting line is perhaps less attractive than a place where we have the blue of an electric arc, the white of a mantle burner and the yellow of an incandescent electric lamp.

There is a certain office where, as far as the lighting arrangement is concerned, cheapness is evidently the primary object. The lights are places is such a position that when working at the desk one either sits in his own shadow, or else, as the light comes from the right, one has a constant shadow of the hand. In fact, the arrangement is about as poor as could be conceived of.

Fig. 35 has been selected as a splendid example of how not to do it. Almost all the principles of good illumination have been violated in this case. In the first place, the lights are so placed that, when a man looks up from his work, he will have the bare mantle glaring him directly in the eye. Second, the light from the lamps will strike the paper at such an angle that it will be regularly reflected, with a resultant glare which will soon produce injurious effects. Third, the light is not diffused, and the intensity, therefore, too high. Fourth, sufficient amount of light is not thrown on the work. In fact, this furnishes a very good example for a gas man to show his customers how not to light their desks. A slight change in the office arrangement would immediately rectify some of these errors; thus, if the tables were simply

turned at right angles, the light would come from the left and slightly behind; it would be out of reach of the eyes of the man working on the table, but would, nevertheless, be visible to the man behind him and should therefore be carefully shaded. It would be well in this case to use an opal dome and bobesche which render the light soft to the man behind and give far more light on the work than the present equipment. For the same reason such an arrangement of tables would be better for daylight.

In lighting a window, one of two objects is aimed at, either an illumination of the goods displayed, or else an attraction to the place by means of the lights.

As an example of window lighting, there is a hat store where the main illumination is furnished by electric lamps hidden in trough reflectors, which are not visible outside. In order, however, to assist in attracting the passerby, lamps are placed in large diffusing globes, which, while adding but little to the illumination of the goods below, nevertheless serve to attract attention. Electricity only is used in this case, and it is simply giving an example of a combination of the two classes of window lighting.

HEFNER, HARCOURT AND CARCEL LAMPS

Photometric Investigations by the Physical-Technical Imperial Institute at Charlottenburg on the Relation of the Intensity of Light of the Hefner Lamp to the Ten-Candle Pentane Lamp and the Carcel Lamp.

By Dr. Emil Liebenthal, of Berlin.

[Read before the German Association of Gas and Water Engineers.]

Translated by *Journal of Gas Lighting* (London).

The international resolutions passed in the years 1884, 1889, and 1896 with regard to the selection of an international unit of light have not resulted in uniformity in regard to it. The Hefner lamp, which was adopted in 1896 at Geneva as the practical international unit measure of light, is even at the present time only in use as such in Germany. In France, as a rule, the carcel lamp, and in England the English candle, and since 1898 the 10-candle pentane lamp as well, are used.

The International Photometric Committee, which was constituted by the first International Congress of Gas Engineers on the occasion of the Exhibition in Paris in 1900, at their sitting in Zurich in 1903 again took up the question of an international regulation of units of light. Its proceedings were then governed by two tables which Herr Bunte had prepared for the purpose from older measurements.

Recognizing that, for the time being, there was no prospect of the introduction of a really universal unit of light, the Photometric Committee at Zurich confined themselves to an endeavor to establish generally accepted ratios between the units of light in use in the different countries. It was then decided: (1) That in Germany, France and England new comparative photometric testings should be made between the Hefner lamp, the ten-candle pentane lamp, and the carcel lamp; and (2) that for the time being the ratios shown by Herr Bunte to be the most trustworthy should be adopted for conversions—viz.:

$$\frac{\text{Intensity of light of ten-candle pentane lamp}}{\text{Intensity of light of Hefner lamp}} = 11.4$$

and

$$\frac{\text{Intensity of light of carcel lamp}}{\text{Intensity of light of Hefner lamp}} = 10.9$$

Exhaustive comparative tests have been carried out in the Reichsanstalt in accordance with the first conclusion. The source of light used for the comparisons was a constant incandescent electric lamp. The humidity of the air varied between 3 and 17 volumes per 1,000 volumes of dry air free from carbonic acid; the barometric height varied between 742 and 772 millimeters.

Two of each of the foreign lamps were used. They were placed at the disposal of the Reichsanstalt by the German Association of Gas and Water Engineers through the medium of Herr Bunte. Screens were placed in front of the lamps, allowing the light to pass, but screening off the parts of the lamps.

THE TEN-CANDLE PENTANE LAMP.

This lamp consists of a Sugg type of argand burner, fed with pentane air gas, which is obtained by the air traversing a reservoir charged with pentane, and furnished with a series of chambers placed above the burner, so that the air becomes thus carburetted with pentane vapor. The reservoir is connected with the burner by means of an india-rubber tube. A metal chimney induces a strong draught of air, and screens off the upper part of the flame. The internal supply of air for combustion is previously warmed. The chimney has an inspection window, with a horizontal mark about its middle. The flame must, according to the prescription, be so regulated that its tips are midway between the lower edge of the inspection window and this horizontal mark. The height of the flame falls continuously for the first few minutes after lighting, so that the gas supply has to be correspondingly increased. After about ten minutes, the lamp attains a nearly stationary state, and then requires,

in contradistinction to the one-candle pentane wick lamp, no longer constant supervision. The light rises very rapidly at the beginning, and after about ten minutes attains a nearly constant value.

The ten-candle pentane lamp proves much more sensitive than the Hefner lamp towards vitiation of the air. When the photometer-room at the Reichsanstalt, which is sufficiently large (16,600 cubic feet), was aired before the beginning of a test, but not again during it, the light of the Hefner lamp decreased by about 2 per cent. at the extreme after three hours had expired, while the light of the ten-candle pentane lamp frequently decreased by the same amount after twenty minutes had expired. According to Harcourt, the light of the pentane lamp does not vary if the flame fluctuates by as much as 6 millimeters above or below the prescribed height. According to the tests of the Reichsanstalt, this is nearly right if the flame is higher than prescribed, but not if the flame is smaller. If the points of the flame play about the lower edge of the inspection window, the light is about 3 per cent. lower than the normal. For exact measurements, this lamp must therefore be regulated to a particular height of flame—like the Hefner lamp and the one-candle pentane lamp.

One of the two pentane lamps was accompanied by a certificate of the London Gas Referees as to the correctness of its measurements. With the other lamp, deviations from the dimensions given by the Gas Referees were not found. The height of flame was regulated according to the prescription. The testing was begun about ten minutes after lighting up. Each time at least two measurements were made, both consisting of the mean of ten photometric settings. In order to avoid vitiation of the air, the photometer-room was aired before each measurement. The flames were not regulated by means of the taps on the carburettor, but by a pinch-cock on the rubber tube connecting the carburettor with the burner. The latter arrangement admitted of the observer controlling the height of the flame at a relatively great distance from the lamp. But, notwithstanding these precautions, the variations in the light of one and the same lamp with the same fuel and under the same meteorological conditions amounted to upwards of 1 per cent. in the course of several hours. The light of the portion of the flame that was beneath the lower edge of the chimney was measured in accordance with the prescription.

Three descriptions of pentane were used in the testings: (1) English pentane—*i. e.*, made in England, and sold by the firm of Carless, Capel, and Leonard, of London. (2) Three batches of pentane made in Germany by the firm of C. A. F. Kahlbaum according to the prescription of the Gas Referees. (3) So-called "Kahlbaum pentane" stated by the firm to be a simple chemical body of the formula—

$$\frac{CH_3}{CH_3}\!\!>\!CH - CH_2 - CH_3$$

Descriptions 1 and 2 were tested in the chemical laboratory of the Reichsanstalt according to the testing prescription of the Gas Referees. It was thereby found that the three consignments of pentane No. 2 conformed to the prescriptions. Description 1 had rather too high a specific gravity (0.6275 instead of 0.626); but in other respects it conformed to the specification. The deviation of specific gravity had evidently arisen from a portion of the liquid having been lost by fractional evaporation during transport in a not absolutely closed vessel. The two lamps gave on the average the same light with descriptions 1 and 2, and on the average about 1 per cent. lower with description 3 than with 1 and 2. An older lot of description 3, which had been extensively used before these comparative testings were undertaken, had given on the average the same value as descriptions 1 and 2.

It was found, on the average of 47 series of testings with pentane 1 and 2, and on the basis of the same humidity, that—

$$\frac{\text{Light of pentane lamp}}{\text{Light of Hefner lamp}} = 11.$$

The greatest deviation from the average value was 2.2 per cent., and the mean ± 1.1 per cent. The average barometric height was 7.59 millimeters. By Hefner "candle," the Reichsanstalt understands the light of the Hefner lamp in dry air free from carbonic acid, and containing 8.8 liters of aqueous vapor to a cubic meter of dry air.

According to measurements made by Paterson, the light of the ten-candle pentane lamp decreases on the average by about 0.66 per cent. when the moisture increases by about 1 liter. The Reichsanstalt finds in place of 0.66 the slightly smaller figure 0.55. Earlier measurements of the Reichsanstalt had likewise given the number 0.55 for the Hefner lamp and the one-candle pentane lamp. Consequently these three lamps are affected by the humidity of the air in the same degree within the limits of error of observation.

When the height of the barometer rises by 10 millimeters, the light of the ten-candle pentane lamp increases, according to Paterson's observations, by about 0.8 per cent., and according to the Reichsanstalt's by 0.6 per cent. For the Hefner lamp and the one-candle pentane lamp, the Reichsanstalt had previously determined the corresponding factors at 0.1 per cent. and 0.4 per cent. respectively. With the

ten-candle pentane lamp, therefore, the effect of atmospheric pressure is still greater than with the one-candle pentane lamp.

The light of the ten-candle pentane lamp, at 8.8 liters of aqueous vapor to 1 cubic meter of dry air, and at 760 millimeters pressure, therefore equals 11 Hefners. At the National Physical Laboratory in London, the light of the pentane lamp is regarded as normal with the average atmospheric humidity applicable to London of 10 liters of aqueous vapor to a cubic meter of dry air. According to the author, the light of the ten-candle pentane lamp at 10 liters aqueous vapor and 760 millimeters is equal to 10.9 Hefners.

Earlier measurements on the ratio of the light of the English candle (with the flame 45 millimeters high) gave a value of 1.14 times that of the Hefner lamp. Therefore it would have been expected that the ratio of the illuminating power of the ten-candle pentane lamp to that of the Hefner lamp would be 11.4. According to the measurements of the Reichsanstalt now reported, the illuminaing power of the ten-candle pentane lamp is therefore about 4 per cent. lower than 10 old English candles. In other words, the new English candle (or pentane unit) derived from the ten-candle pentane lamp is about 4 per cent. smaller than the old one established through the spermaceti candle.

CARCEL LAMP.

The carcel lamp is well known to be a simple modification of the circular-burner lamp with double air draught, constructed by Argand towards the close of the eighteenth century. It is fed with purified colza oil, which is pumped up to the burner from a reservoir fitted in the base of the lamp, by means of a clockwork pumping arrangement. A glass chimney having a choke is set on the stop on a ring-shaped tube which can be altered as to its height on the burner tube.

Each lamp was accompanied by a can of colza oil and a set of wicks. The fuel was used in turn in the two lamps. The lamps were so regulated about 30 minutes after lighting that the wick projected about 7 millimeters from the burner. This was in accordance with M. Laporte's practice, as distinguished from the 10 millimeters which Dumas and Regnault prescribed in 1842. The choke of the chimney was 7 millimeters above the upper edge of the wick, and hence 14 millimeters above the rim of the burner. The hourly consumption of fuel generally was between 42 and 45 grammes. The photometer tests were begun about 50 minutes after lighting up. Before each testing the lamps were furnished with new well-dried wicks, and filled to the gallery with fuel. As the carcel lamp is tolerably sensitive to vitiation of the air, as Laporte has shown, the photometer-room was aired from time to time. Both lamps gave an average value for the light which agreed with one another within the limits of error of observation.

In all, 28 series of observations have been made, each of which comprised at least four directly consecutive measurements. Each such measurement included a determination of the consumption and a number of photometric settings. The consumption was deduced from the time required for the consumption of 10 grammes of oil. Several measurements were made one after the other each time, as during the testing the consumption varied up and down while the light increased comparatively little with the time.

On an average, it was found that, on the basis of equal humidity—

$$\frac{\text{Light of the carcel lamp}}{\text{Light of the Hefner lamp}} = 10.8.$$

The greatest deviation from the mean value was 4.6 per cent., and the average 1.8 per cent. There is still to be taken into account that the figures from which the mean value 1.08 was deduced vary among themselves upwards of 10 per cent. The lamp, therefore, does not give exact values.

Old measurements made the ratio of the lights of the two lamps as follows:—

Dutch Photometrical Committee (1894)	10.4
Lecomte (1904)	10.5
Durand and Jigouzo (1896, published in 1898)	10.8
Laporte (1898)	10.9

Laporte has also compared a carcel lamp with two of the incandescent electric lamps of 10 and 16 Hefners power tested by the Reichsanstalt; and from this indirect comparison he found a ratio, on an average, of 10.8.

The measurements carried out by the Reichsanstalt with the carcel lamp are so distributed in point of time that the mean value found relates to about the average humidity in the course of a year. On drawing the mean intensities of the different series of measurements in rectangular co-ordinates as a function of the humidity, the points obtained fall within a belt of which the axis is about parallel with the abscissæ axis. It therefore follows that tne dependence of the light on atmospheric humidity, so far as it can be detected with the considerable fluctuations in the light, is nearly the same as with the Hefner lamp. Assuming that in the neighborhood of the average humidity, the relation is the same for the two lamps, it follows that the light of the carcel lamp, with a humidity of 8.8 liters of aqueous vapors to 1 cubic meter of dry air, is equal to 10.8 Hefners.

ORGANIZATION AND CONDUCT OF A NEW BUSINESS DEPARTMENT SUITABLE FOR CENTRAL STATIONS IN CITIES OF 50,000 POPULATION AND UNDER *

By S. M. Kennedy.

There is probably no other kind of business in America today which is capable of as much development as is the selling of electric energy. At first glance, this may appear to be a bold assertion, but the more the subject is considered, the more the truth of the statement will become evident. There are countless opportunities for working fields only partially cultivated, for plowing and sowing fields now lying fallow, and for reaching out into the deserts and making them "blossom like the rose." It matters little what may be the relative size of the city in which a central station is being operated—whether it contains 5,000, 50,000, or 500,000 population, the opportunities are there in each case and almost begging to be looked after. However, opportunities are not in the habit of rushing at those who sit down and wait for them; they require to be sought. But many a man who is sincerely looking for Opportunity will be surprised to find that Opportunity has been loking for him, and anxious to meet him more than half way. Electrical opportunities are everywhere in any city, on the streets, in the home, in the office, in the factory, in the store, and in the work-shop—on the surface, overhead and underground—wherever men and women live, eat and sleep.

NEW BUSINESS.

There is no standing still in the electrical business and a central station is either going ahead, or falling back. As a matter of fact, really healthy electric company should be behind with its new work most of the time, should be rushed with orders and straining to keep up with them. It is not meant by this that there should be inefficient methods, or insufficient help, but that the pressure of constantly increasing demands for electric energy should be impatiently pushing forward the orders awaiting their turn for attention.

But this great pressure of work, these insistent demands for attention—what are they? Just the visible indications of opportunities which have been stirred up, and opportunities which have been met on the way in. And the central station will obtain the full advantage of these opportunities by means of its "New Business Department."

OBJECTS.

The great problem which central station managers are trying to solve, is one of equalization. It is highly desirable to increase the sale of electric energy in every legitimate way, but some ways are more profitable to a company than others. In a growing city it is an easy matter to build up a "peak." But it takes efforts and brains to broaden the "peak," to build up a day load and to reduce the difference between the peak load and the minimum demand. These are prime reasons for the existence of a "New Business Department." It is to this department that the central station manager must look in order that he may obtain a proper load for every hour of each day, and every day of the year.

FOUNDATIONS.

In organizing such a department, it is well to consider what are the requisite foundations upon which to build: In the first place, there should be a corner stone on which is graven the words: "Electricity for Everything, and Everything for Electricity." This should be adopted as the motto and slogan for all connected with the department. With such a corner stone, the remainder of the foundation should consist of: (1) Energy—untiring, unswerving energy—the kind which never stops. (2) Vigilance—the watch-dog of progress—the sleepless element which takes advantage of every opportunity. (3) Alertness: quickness to see an opening for business, and readiness to act upon it. (4) Aggressiveness; so that old methods and conditions may be sucessfully combatted and changed to conform with modern ideas. (5) Persistence; in order that prospects may be converted into actualities. (6) Knowledge; which is the mother of good judgment. And (7) Enthusiasm; the quality which compels by force of belief—the combination which oils the mechanism of a business and cements the forces for a common cause. These are the principal elements which are required as a safe foundation for a New Business Department, and with a proper admixture of each, the superstructure will grow of its own volition.

STAFF.

A New Business Department is no longer considered an experiment or a fad—it is a necessity in the operation of a central station. The generator is the heart of the plant, but the New Business Department is the lungs. A man cannot get along without a heart, neither can a central station. A man can get along with only one lung, or a part of a lung, but he will die

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if the part shrinks up too much—and so will a central station. For cities of 50,000 population and under, the staff of a New Business Department proper, may consist of from one to twelve individuals, depending altogether on the size of the city, the local conditions, and the rate of speed with which certain objects are to be attained. There has been an inclination in some quarters to look upon this department as an extravagance, which tended towards excessive plant investment. But this theory is easily exploded. A properly organized and well operated New Business Department not only points the way to profitable extensions, but increases the value of present investments by developing paying business existing under a company's lines and selling energy during those hours when it would otherwise be wasted, or, at least, not fully utilized. Let the central station manager select a good man to put in charge of the New Business Department, and let that man add to his assistants as he feels the necessity, and as circumstances warrant. An energetic man will soon stir up more business and more prospects in a city of 10,000 inhabitants than he can take care of himself, and he and those laboring with him will have pleasure in watching the growth of the new business added as the direct result of their efforts.

THE WORK.

It is safe to say that no city on this continent, no street, no block, and no house can claim to be properly illuminated, or to have all the electricity consuming devices which might be used with advantage. It is safe to say that in every city of any size there are hundreds of horse power in steam and gasoline engines being operated at a greater cost than necessary, just because their owners have wrong ideas about electric energy and are not aware of the great advantages to be derived from its use. It is safe to say that there are many electrical appliances which could be installed in each household now using electric light. In every community there are many thousands of dollars in revenue waiting to be picked up from the sale of current, the production of which would not increase the central station plant investment to the extent of one cent. As a matter of fact, the people really want to know all about the possible advantages of electricity, and this curiosity should be stimulated and satisfied by the central station, as it is entirely in line with the growth of its business. More light and more power can be sold to consumers, as well as non-consumers,—but it must be done by hard work. Men with a knowledge of salesmanship and business methods are required to successfully spread the news of electrical possibilities, to swell the number of consumers, and increase the amount of individual consumption. This is the kind of work cut out and waiting for the New Business Department.

NEW METHOD.

But if it is discovered by a manager that so much valuable business is waiting attention, what must he do to gather it in? Well, there are four ideas which he must grasp before starting on his campaign, namely, that the public requires Education, Instruction, Persuasion and Demonstration. It is not usual for men or women to want something which they do not know exists. And after they have been taught that something does exist which would better their condition, they require to be instructed as to its advantages. In a city of 20,000 population, a company may have 3,000 consumers—all using light. Perhaps the manager contentedly leans back in his office chair, and, in answer to an inquiry, says: "Yes, business is good, we keep adding to our consumers right along, and must soon increase the capacity of our plant." And at the same time his load curve may probably resemble the spire of a church as much as anything else! Does he try to broaden his "peak?" Does he try to equalize, so that there may be a profitable day load? May be he is too busy to do more work himself. If such is the case, then he had better obtain a means of educating his public. His 3,000 customers could probably be increased to 4,000—but, let us stick to the 3,000. They are all using light—Splendid! What do they want first? More light! It is an axiom, in this business, that the more opportunities there are for using light, the more light will be used. Some of the residences are without porch lights, hall lights, portable lights, cellar lights, outhouse lights, and outdoor lights. The stores want more inside lights—and more electric signs. The factories and workshops need more arc and reflector lamps—good light makes cheerful and efficient workmen, and good workmen deserve good light.

ELECTRIC APPLIANCES.

What next! Do those householders know of all the electric appliances which add so much to the comforts of life? Well, may be they do know of some of them—but not from the central station office. And yet those housewives are ready to use electric toasters, chafing dishes, irons, sewing machine motors, plate warmers, coffee pots, curling tongs, broilers and a dozen of other conveniences. But they must be told about them.

Anything else? Yes, Just POWER—but spell that word with capitals, for it usually means day load, and that is what our friend, the manager, is looking for. That city of 20,000 is using lots of power in intermittant and constant operation.

How much of it electric? Is the manager going to sit down until new factories start, and wait for the promotors to come to his office and inquire what can be done? If he does, he will probably have few inquiries. Is he going to wait until those existing power users who have steam and gasoline plants meet with accidents and then expect to have them ring up for information? Well maybe he'll have a few calls, but he'll have fewer orders.

What must be done to obtain these valuable kinds of business? Educate, Instruct, Demonstrate, Persuade. If you want to sell more light, show your customers that they need more. If you want to derive the increased income from the use of electric appliances without increasing your investment, you must create a demand for the appliances. If you want power consumers to hold your plant down during the daylight hours, then show the power users in your city the advantages of electric energy. They must learn of the convenience, cleanliness, and reliability of electric motor driven power. They must be shown the saving in insurance, interest and depreciation. They must have all these things explained and demonstrated to them. They must become interested, then anxious, then hungry.

ELECTRIC IRONS.

The company with which the writer is conected operates in one city with a population of 225,000, and in seventeen other cities with populations varying from 4,000 to 25,000 and has upwards of 30,000 electric consumers. About eighteen months ago it was decided to stimulate the sale of Electric Laundry Irons for use in private dwellings, some hundreds having already been installed in various laundries on the system and found to be giving great satisfaction. Within twelve months there were installed in residences over 1,600 irons, which were all paid for by the consumers using them. Careful data was compiled and it was conservatively estimated that the average monthly income from each iron was sixty-five cents or equivalent to $8.00 per year. It was also apparent that those who had the irons were highly pleased, and, in numerous instances, were inquiring for other appliances. But many did not have the irons that would gladly use them, who could not or would not spend the money to buy them. Now, here is what the company discovered: Electric irons were good things; day load; lighting rates; no increased plant, line, transformers or meter investment; average income at least eight dollars per year; 1,600 of them installed! Why not 10,000? But the people won't buy them! Well, let's see! Every thousand irons out increases the annual income $8,000; 10,000 irons would mean $80,000! Just like finding it! What was to be done? Invest a little money. Take a little risk. Loan the irons to customers who will use them.

That is what our company has done. The first order placed was for 3,500 irons, and within twelve months from the time the plan was put into effect, the company will have loaned not less than 7,500 irons, and there will probably be in use on our system altogether 10,000 electric irons in 1907. That is one way of getting new business and making it easy to obtain more.

BUYING OLD PLANTS.

One more reference to the means adopted by the same company to obtain power business. It often happens that a power user may be interested in electricity, but he has his money tied up in a steam or gasoline engine and does not wish, or thinks he cannot afford to invest more. During the past two years our company has purchased such plants, in units averaging 20 h. p. each, to an aggregate of over 1,000 h. p. These engines have been resold and shipped to territories away from the company's lines, and their former owners are now invariably strong advocates of electric energy. But engines have only been purchased in this manner where there was no other way of obtaining the electric power business. Owing to the lower cost of motors, most of these exchanges were made without loss to the company, although in some cases it was figured out that an initial loss must be met in order to obtain profitable and permanent power business.

WAYS AND MEANS.

And now we come to the question of ways and means. How is the public to be educated, instructed and persuaded? What is it that the new business department must do to begin with, and what must it continue to do? The answer is:

Advertise,
Solicit,
Exhibit,
Systematize,
Foster Existing Business.

The sucess of the central station is first dependent upon good service, but most of the different problems in generation, transmission and distribution have been satisfactory solved, and most managers know how to obtain an adequate amount of energy. But the limits to the sale of electricity have not yet been sighted, and the more these limits are sought, the greater distance they seem to be away.

The New Business Department cannot be divorced from the other departments of the company. It must, of necessity keep in touch with the operating and construction ends, must be close to the accounting side, and in constant communication with the customers' department. The manager of the New Business Department may not be an engineer, but he must have absorbed a considerable amount of technical knowl-

edge. He may not be an accountant, but he must know how to figure. He may not be a meter reader, a collector or a trouble man, but he must know what are the difficulties in each position. And, above all, he must know the public. He must know its failings, its prejudices, its needs and its opinions.

ADVERTISING.

In the conduct of a New Business Department, the subject of advertising is ever present. It is one of the main stays, and must receive careful attention. But let us take it for granted that the manager acknowledges the importance of advertising—the next question is, what are the best methods of publicity? Probably more than any one else, the man who advertises must put himself in the place of those whom he wishes to reach. With this idea before him, he will understand how to attract the attention of the public, where to place his advertisements, and when the psychological moment arrives, to produce the best results. Now, advertising of any description must attain its object by a well defined process. In the first place, it must attract attention, next promote inquiry, then awaken desire, and finally create a demand. Again it is asked, what is the best medium for doing all this and increasing the sale of electricity? For the reason that the public cannot be all reached in the same way, it follows that all honest advertising is good. Some people never look at the advertisements in the daily papers, but will eagerly scan each advertising page in a magazine. Others never see an ad. in a periodical, but yet their eyes catch the notice on a bill board, or the card in a street car. Again, there are others too absent-minded to note anything on bill board or in car, but put a circular or letter in their hands and it will be read from beginning to end. Consequently, if you wish to reach every class, use every medium of attracting their attention. You don't require to go after all at once—but go after them somehow.

NEWSPAPERS.

Newspaper advertising pays in many ways, its returns being visible and invisible. It frequently happens that considerable space is taken in order to propitiate the press. The friendship of your local papers is important. Foster that friendship, but do not neglect the space you take just because you think it is there always, and the ad. may be changed at the same time. That space is valuable to you in proportion to the circulation of the paper, just as the editor may be valuable to you for the same reason. If your ads. are built right, if they attract attention and SAY SOMETHING, they will help your business, and increase your income. It is a good plan to tell one thing at a time, to change the copy frequently, so that it may not become stale, and to use a snappy concise style which will gradually draw a regular following of readers, who will look for your ad. in the paper just to see what you have to say. What you print will be read by consumers and non-consumers. Say something to each. The first named should be using more current. Point out to them where they need more. The others need to begin. Show them where they will be better off. Create the desire. You do not require to be an advertising expert. Know your own business. Be thoroughly acquainted with the public needs. Talk in the ad. as you would to a prospective customer sitting in your office. Attract attention—then be short, direct and crisp, and let your words show that you believe in what you say and they will carry conviction with them.

Regarding the many valuable media of advertising other than newspapers, the business manager must, of necessity, be governed by local conditions and his own experience as to the advantage of each class. It is desirable to vary the manner of publicity, but to keep at it all the time, remembering that constant drops of water will wear away the stone, and that indifference may gradually be changed to interest, and antagonism to friendship.

CIRCULARS, ETC.

The mailing of circulars separately or along with bills is a successful way of arousing interest, but the circulars require to be carefully prepared—printed on good paper and always artistic. Neat booklets or folders should be inter-changed with the circulars, and each should draw attention to one subject only. Bill boards are splendid for special announcements and catch the eyes of many who will not read the papers. He who runs may read a poster—and many read and remember. Street car advertising is also valuable to impress an idea on the public. If a man is sitting in a car for ten or fifteen minutes and one of your ads. is opposite to him, he will read it whether he wants to or not. And if what you say is catchy or important, he will not forget it.

"FOLLOW UP" LETTERS.

"Follow Up" letters are a dignified and desirable means of drawing the attention of selected people to a subject which should be of special interest, and are always productive of good results. These letters should have a personal touch to them, and should be neat and attractive in style and diction, avoiding altogether the appearance of a general circular. By this means the individuals you wish to reach are talked to without chance or haphazard.

It has been found that one of the best ways of drawing attention to a subject with existing consumers is to use the backs of monthly bills. If you wish to advertise

electric appliances useful in a home, put a snappy notice on the backs of the bills. If you wish to have merchants consider window lighting, electric signs, or fans, talk to them briefly on the backs of their bills. Say something different each month. Somehow every man and woman will look at an electric bill to see the amount. When they see the amount let them also notice a bold line reading "See Other Side." They'll turn the bill over and read your ad. That's what you want them to do.

ADVERTISING ON BILLS.

The new business manager should do his advertising well, thoroughly, intelligently, and systematically. If he cannot do it himself, or have some one on his staff who can, he had better pay an ad-smith to take the details of the whole matter off his shoulders. But let him advertise and do it right.

Advertising in the electric business is principally to arouse curiosity and invite investigation. Its object is to induce the reader to ask questions, and prepare the way for getting business. But it requires a personal interview to close a contract; and the prospective consumer must either hunt some one up, or some one must hunt him up in order to bring matters to a desirable climax. It is a good plan for a representative of company to do the hunting. The man who reads the ad. might have good intention, but a bad memory.

SOLICITING.

"The best cause requires a good pleader," and the best managed New Business Departmet requires good solicitors. There are some lines in which a solicitor requires only to be a good talker. Not so in selling light and power. A good talker is all right, but he must first be honest and straightforward. and what he says must carry with it the ring of truth. The solicitor goes out among the public. He meets the people in their homes, offices and places of business. He does not represent himself, he represents the company, and the public is going to judge the company by the action and words of the solicitor. Often he is the only one about the company whom the customer knows. The president, directors, and officers may be men of standing—great men in the community—but the average customer does not know anything about them. He judges the officers by the kind of men they send out to talk to him. Do not think that any kind of a man can solicit. Have men who KNOW; men who can make friends; men who can mix well and men who wear well.

REGULAR SOLICITORS MEETING.

There is a great difference between a man coming to you to do business, and you going to him. The first presupposes a desire in him to act; the second a desire in you to induce him to act. Consequently, solicitors should be trained and instructed. In this connection it is well for the manager of the New Business Department to gather his staff around him at least three times each week to discuss matters in hand, to answer questions and smoothe out difficulties. New conditions are constantly arising which require to be met. Information is constantly coming in which requires to be distributed. Reports about new buildings, new building permits and new tenants must be dealt with, and often a daily meeting is necessary—and advantageous. Direct solicitation is the safest and surest way to obtain business, and the solicitor must be equipped for his work. The electric company has much to do to overcome competition, indifference and inertia, and it is through the solicitor that a large amount of this active and passive opposition may be removed. He must educate and demonstrate. He must make the public realize that what his company is selling is something in which every one should be interested; something that lessens the cares and responsibilities of life; something that is superior to everything else for doing similar things; something that reduces work, lightens labor and saves their pocketbooks from certain ravages.

SOLICITOR'S TACTFUL WORK.

It is essential that solicitors should not be too technical in their talks with prospective consumers. There is nothing to be gained in befrogging a man by injecting into a conversation a mixture of amperes, ohms and volts. The solicitor is not selling kilowatts; he is selling light. He is not selling amperes, he is selling heat and power. If he has acquired technical knowledge, let him forget it when talking to an ordinary man or woman, and he will sell electric current with less trouble. Those engaged in the electric business are apt to forget that the public does not know as much about it as they do. It is a fact that a very large percentage of the community does not know of the conveniences and simplicity of handling the current,—even when they have it for lighting their homes. Many people have a fear of electricity on account of its mysterious nature; some thinking it as dangerously as lightning. Here is where the careful work of the solicitor may do good every day. He can point out the safety of electricity in the home, the impossibility of upsetting electric lights, and, consequently, the reduction of fire risk; the dispensing of matches where there are children and careless people; the abundance of pure air, the saving of doctors' bills and the convenience of the many wonderful electric appliances which are adapted for house use.

To the merchant the solicitor points out the advantages of electric light for showing his goods. For keeping his ceilings and store clean, by an absence of smoke and

smut, for reducing the heat in summer, and permitting good air at all times. For improving the decoration of his windows and keeping them clean winter and summer, so that the public may see what he wishes to display. And then he shows him the score of electrical devices which may be operated to advantage inside his store, and help him make money. And, lastly, the solicitor takes his merchant to the door and points out how and where an electric sign will work for him while he sleeps; how he can burn his name and business into the public mind, and how the company will take care of the sign, turn the current on and off at the proper times, and relieve him of all responsibility in the matter.

APPLIANCE SHOW ROOM.

The power user has much to learn, and to a great extent the solicitor must be his instructor. He goes into a factory in the crowded part of the city, and what does he see? Probably fifty per cent. of the power generated wasted and dissipated in shafting and belting before the machine commences to work. Probably ten times as much space as is necessary given up to engines and boilers—and valuable space, too. Probably twice as much money invested in the power end as there should be, and, consequently, twice as much interest and insurance, and four times as much depreciation continually piling up. He probably finds plenty of noise, smell, dirt and inconvenience, to say nothing of high priced skilled labor to keep the wheels moving. Little by little the solicitor can show that electrically driven machinery represents economy of power by means of direct connected units; that motors occupy little space and may be taken off the floor and stuck on the walls and ceilings; that they cost less than half the price of any other kind of power machinery; that they are clean, noiseless, convenient, and reliable, and do not require skilled labor to operate them. The work of the solicitor may be greatly aided by the company having a show room in which all kinds of electrical appliances, big and little, may be seen and their usefulness and convenience demonstrated. The public may thus become familar with the workings of the different apparatus, and the solicitor will have an advantageous place to which he may invite prospective consumers, and there explain the actual operation of what he wishes to sell. Too much care and attention cannot be given in the arrangement and fit-up of this room. Lamps of every size and design should be tastefully displayed so as to obtain the best effects out of each. With them there should be shown the current saving devices, and also electric motors in operation. The latter will help to educate the people to be familiar with the meter's mechanism, and tend to inspire confidence. Then there should be specimens of all sorts and varieties of practical appliances which may be used in the house, office, store, and workshop. In short, a continuous exhibition of what may be had in electric apparatus and what may be done with them. In this show room there should always be plenty of small booklets, giving illustrations and concise information regarding the different kinds of appliances, so that those inspecting them may have something to carry away to refresh their memories, and arouse the interest of others.

ELECTRIC OFFICE DISPLAY.

But the manager of a central station must show his belief in what he produces and sells by using freely what he wants OTHERS TO BUY. He preaches that an electric sign is the best kind of an advertisement. Does his company use one? He advocates a well lighted store and a brilliant window. But how about the company's office? Is there plenty of light, and is it burned far into the night? Has he electric fans, footwarmers,and radiators installed for the benefit of employees and customers? What is the use of his saying that "trade follows the light" if he does not illuminate his own premises. If he has no electric sign over his office, what is the use of his preaching that the same law which draws the moth to the flame of the candle, also draws the buying public to the brilliantly lighted store.

SYSTEM.

It was Thomas A. Edison who said that "genius is partly inspiration, but mostly perspiration." In other words, energy is what produces results. But much energy may be lost because it is not systematically applied. The manager of a new business department will find that system is a good servant for him to employ. The larger the business transacted, the better must be the system, and that system is best which substitutes knowledge for guess-work, and economize time, labor and money. There must be system in advertising, and system in laying out the work for solicitors. There should be system in noting the results of advertising and the returns which solicitors bring in. There will be inquiries, leads, and prospects, the data concerning which requires to be kept up to date and accessible. There should be system in handling what has to be done, and what has already been accomplished. System in noting sales, terms, proposals and contracts —records of buildings to be constructed, names of owners, contractors and tenants, and the particulars regarding the probable requirements of each. In records of prospective power consumers, complete information is necessary about present installations, kind of machinery, makers' name, horse power, use and hours of operation.

CARE OF CUSTOMERS.

In all branches of the New Business Department's work, system is needed, but not the kind of system which becomes a tax and a burden. The longer he is at his work, the longer he is dealing with the people, and the longer he is trying to sell electricity, the more will the new business manager be impressed with the fact that the best advertisement is a pleased customer, and the best possible solicitor is a consumer who is satisfied. All the work of his department is practically wasted if the new business taken on is not properly cared for. It is a regrettable fact that, as a rule, there does not seem to be a proper sympathy between the public and the electric company. They do not seem to understand each other. The public is too liable to think it is being overcharged or imposed upon, and the employees of the company to think the public kicks too much. And the fact is still further to be regretted because the companies are largely responsible for this condition. Employees are not trained to be courteous and polite, to put themselves in the customer's place, and understand why they ask questions about what they do not know, and why they "kick" when those who are taking their money do not give them proper attention and civil answers. The importance of this subject cannot be over estimated, because it is up to the company to do everything possible to establish and maintain friendly relations with its customers. The New Business Department must be backed by good service, and "good service" only begins with the production of the current. Good service requires that there should be polite and attentive clerks, collectors, meter readers, and trouble men; that complaints shall be listened to and promptly investigated, and the settlement of disputes and adjustment of claims shall not be sidetracked and postponed beyond reason. The very existence of a company depends upon the good will of its customers.

GOOD SERVICE.

The agents of the New Business Department go out after business. They approach a man in his own house or office, and then it is that a man is liable to talk freely of how the company has treated him. If the treatment has been bad, the agents chances of doing more business are very slim. If the treatment has been good, the chances for more business are excellent. Again it is pointed out that the best means for advertising a business is to be advertised by its friends. If a man is a consumer, look after him. If he has a complaint or is in trouble, give his case immediate attention. His general opinion may be that corporations have no souls, but he will find that individuals in the corporations have, and it is by the work of the individuals that he is going to judge your particular corporation. If a man is a power user, he is depending on that power to help him earn his daily bread. He may have a large number of employees, or he may be operating a motor by himself. In either case, if the power goes off, or some trouble occurs with his service, he is put to inconvenience and expense until the trouble is rectified. As a rule when he has trouble with his motor or service, the first thing he does is to call up the electric company. The first thing the electric company should do in such a case, is to give this man's trouble the right of way. Whether the cause of the trouble is the fault of the company or the consumer does not much matter; the fact that the consumer is shut down is sufficient reason to see that he may be running again as quickly as possible. It is this kind of treatment that makes friends for the company. It will be found that one of the most successful ways of convincing prospective power users that the energy you have to sell is the energy they need, is to take them to plants which are being operated by electric power for similar purposes to what they would use it. Then have these consumers who have been using power for sometime tell the prospective customer how electricity works; what are the advantages and troubles (if any) and what is the cost of operation. The prospective customer is liable to think that the agent of the company is prejudiced, and you cannot blame him. Besides, the man who is trying to sell him a steam or gasoline plant has probably told him something just the opposite to what your agent has said. But if he is going to run a machine shop, or a planing mill, or a foundry, or a peanut stand, take him or send him to some of your customers who have been running similar plants with your electric power.

RESULTS.

However, results are the best test of all work, and there is nothing problematical about the results to be obtained by a New Business Department if it is operated with Diligence, Intelligence, and Perseverence. Let the department manager cultivate among his assistants a spirit of pride in the work. Let him encourage and enthuse them, so that a healthy emulation may exist; an emulation to excel each other for the benefit of the company's business, and to pull together, so that the successes of to-day may be but the stepping stones for the achievements of to-morrow. Let there be politeness, attention, and courtesy in all makes and at all times, and under such conditions the central stations will surely prosper and the tiny stream of new business which once had to be coaxed and persuaded, will eventually begin to flow as a river, and continue to grow in force and volume day by day.

Review of the Technical Press

AMERICAN ITEMS

THE LIGHTING OF LARGE PUBLIC ROOMS. By J. R. Cravath and V. R. Lansingh.—*Electrical World*, July 7, 1906.

The article is illustrated with a considerable number of photographic reproductions of well known buildings. The general instructions for the lighting of such buildings is as follows:

"In the lighting of hotel lobbies, large railroad depots, main floor halls of large buildings, etc., the object to be attained is a general cheerful effect, good illumination on the floor, and absence of glare. Glare in such places invariably looks crude and cheap. Its only legitimate use is in cheap advertising by electric light. The day has passed when it is to be tolerated in high-class buildings. The object should be to produce a brightly lighted and cheerful effect without bringing the sources of light into glaring prominence."

The union depots at Indianapolis and at Pittsburg are shown as illustrating the old and new practices in lighting, the former being "lighted with enormous and elaborate chandeliers hung high from the middle arch, while the latter is lighted in an unusual but very effective manner by means of six glower Nernst lamps hung in the space between the first and second skylights. The result is an excellent diffused light coming through the skylight giving the same effect as when the room is lighted by daylight. The effect of the lighting is on the whole extremely good and one can easily read anywhere, a desirable quality in a waiting room." The illumination of several prominent hotel lobbies is then critically reviewed. In describing the lighting of a theater lobby they say:

"The lighting is done by upright bracket fixtures equipped with ground glass globes and basket fixtures hanging from chains. The greater part of the lighting is done by the bracket lamps. The principal thing to avoid in a location of this kind is the use of opaline globes, which do not diffuse the light to any extent and which show the lamp filaments through the glass, these filaments having a sickly red hue and producing a general crude effect out of keeping with the surroundings. Globes selected for use in such a place should either be of frosted or sand blasted, or a sufficiently dense opal employed so that the lamp filaments will not show through."

The lobby of the Hotel Jefferson, in St. Louis, is given as a good example of indirect or diffused lighting. On indirect lighting they further say:

"In the ladies' parlor of this same hotel, which is lighted the same way, there are 65 10 c. p. lamps. The room is oval in shape, being 34 ft. 8 in. long x 26 ft. 6 in. wide. The area is 645 sq. ft. If 56 watt lamps are used, the current required would, therefore, be about 5.6 watts per square foot as against about 2.5, which would ordinarily be ample for a room of this character with direct illumination." Several other examples of hotel lobby lighting are given.

A NEW METHOD OF ASSORTING INCANDESCENT LAMPS ACCORDING TO AGE. By Dr. Clayton H. Sharp.—*Electrical World*, July 7, 1906.

A paper dealing with the problem confronting central stations as to the disposition to be made of returned lamps. Such lamps are thus classified by the writer:

"To all electric lighting companies practising the system of free replacements of incandescent lamps, the proper assorting of the lamps which are returned from their lines is of considerable importance. Experience shows that if all returned lamps were reckoned as useless, the companies would suffer material losses by destroying lamps entirely suitable for useful service." It is stated that:

"The assorting may be planned simply to show whether or not a lamp should be returned to the lines for normal service, or it may be more discriminating. It may divide the lamps into classes, such as (1) those suitable for further service under normal conditions; (2) those which have decreased further in candle-power but which are still useful for certain purposes where high candle-power is not of first importance, e. g., their bulbs may be colored; (3) those which have so nearly finished their useful life that it is not desirable to make further use of them."

The following method is described as followed by the Electrical Testing Laboratories:

"The series of lamps having all degrees of blackening from the faintest to the densest was selected. These were distinguished by numbers up to 9. The blackening of any lamp is determined by locating it in these series and is designated accordingly.

"To facilitate this determination the scale lamps are placed upright in front of a ground glass screen which is uniformly illuminated from behind. Spaces are left between the scale lamps so that an unknown lamp can be interpolated anywhere in the series. By comparing this lamp with the lamps on either side it is easy to determine whether its proper position in the series can be found."

"The bulb blackening gives directly the percentage of its useful life which a lamp has spent. It is also independent of the efficiency at which the lamp has been operated. The lamp alone tells its own complete story without reference to initial or intermediate conditions."

Experiments were carried out to determine whether this scale of blackening could be used in place of photometric measurements. The results obtained showed that the method was quite satisfactory in selecting lamps above 15 candle power and below 14 in which the error was within 10%, but in selecting lamps between 14 and 15 candle power the error was much larger, being about 30%. The method is, however, much easier and quicker to carry out than photometric measurements.

"It is of interest to know what the different steps in this blackening scale are numerically equal to. To determine this, the percentage of light absorbed was measured on a photometer. Several sets of lamps corresponding to the steps of the blackening scale were selected. Each of these was placed in the photometer rotator with a tubular lamp behind it. The percentage of light transmitted was thus determined. Similar measurements were made on new lamps to determine what portion of this light was intercepted by the clear glass and what portion by the carbon coating. After this had been done the bases were removed from these lamps and the absorption of one thickness of the lamp was measured by putting the miniature lamp inside the empty bulb. The results of preliminary measurements are shown in the curve of Fig. 2. It will be seen that this curve is nearly a straight line for the lower members which cover the ordinary range of returned lamps. These results are subject to revision.

"An interesting conclusion from the above is that in round numbers 50 per cent. of the decrease in candle power of a lamp is produced by bulb blackening and 50 per cent. by changes in the filament."

RESIDENCE LIGHTING AND OTHER CENTRAL STATION NOTES FROM CLEVELAND.—*Electrical World*, July 7, 1906.

"The Cleveland Electric Illuminating Company has recently been carrying out some very interesting policies in connection with the extension of its business aomng residences and apartment houses. Special attention is being given to this class of work on the theory that a residence one well equipped for electric light will always be a good customer not likely to go over either to natural or artificial gas. A great effort is at present put forth by the company to see that residences are conveniently wired and that they are equipped in accordance with sound illuminating engineering principles. This is thought to be of vital importance in the growth of the residence business. Some of the older residences and apartment buildings wired for electric light had chandeliers so arranged and equipped with types of glassware that reckoned economy impossible, with the result that the occupants of such buildings are not so enthusiastic about electric lighting as they would be if the lighting had been well planned. The company does not do residence wiring, but acts in an advisory capacity for many of its customers when their houses are being wired. No charge is made for this expert advice. The architects of Cleveland have learned that the company's specialists can lay out wiring arrangements much better than they can themselves, and they gladly turn over the planning of such matters to the company, thereby relieving themselves of this work. This is an unusual condition of affairs, and it is, of course, brought about by the company's willingness to give its services free. While it costs the company something, it is believed that it is the best way to secure satisfactory customers in residences and apartment buildings, and in that way the surest means of building up this class of business."

RARE EARTHS AND ELECTRIC ILLUMINANTS

BY MURRAY C. BEEBE.

From the *Wisconsin Engineer.*

As scientists and engineers have come to a realization of the inefficiency of existing methods of illumination, the problem of improving upon these inefficient methods has received considerable attention. While the element carbon has heretofore been almost exclusively used commercially in both arc and incandescent lamps, the rare earth oxides, so-called, have recently been found to possess desirable properties for use as illuminants.

You are already familiar with the work of Auer von Welsbach in producing gas mantles of thoria and ceria. To use the rare earths, in electric illuminants was a logical step. However, the problem presented difficulties not encountered in the production of a serviceable gas mantle. We should remember that an electric illuminant, to be an improvement over the Edison or carbon-filament lamp in the mat-

ter of efficiency, must be capable of withstanding a higher temperature than the carbon filament for a length of time sufficient to make it commercially attractive. One might at first suppose that it would be difficult to improve upon the carbon filament in the matter of efficiency, or the ability of the filament to operate commercially at a very high temperature, since the carbon is practically infusible while the rare earths are fusible in a carbon arc. Carbon, however, slowly vaporises at the temperature at which it operates in the incandescent lamp, and, finally, after 400 to 600 hours, has depreciated in light-giving power to such an extent that it is an economy to replace it. It is the vaporising properties rather than the melting points of the materials with which we are concerned in this problem. It has long been known that substances which are commonly regarded as insulators, such as glass and porcelain, become quite good conductors of electricity at higher temperatures.

Prof. Buff, in 1854, read a paper "On the Conductivity of Heated Glass for Electricity," and Faraday's "Researches" give a number of examples of such conductors. Jablochkoff attempted to use refractory materials, such as lime, to separate and insulate the carbon electrodes of his Jablochkoff candle. He soon found that these supposed insulators in reality became conductors, and emitted light by virtue of the current passing through them from one electrode to another. He even designed terminals with which to carry the current of electricity to the lime conductor, with the idea of making a lamp based upon this principle. It is probably safe to say that had it been possible to produce electricity as cheaply then as now, lamps of the Nernst type would have been known commercially much sooner than they were, for Jablochkoff's persistent attempts at commercial exploitation were baffled largely by the undeveloped state of electrical engineering.

That the rare earth oxides are exceedingly refractory and do not readily vaporise at a high temperature makes the Welsbach mantle possible; that some of these oxides will conduct electricity when hot makes the Nernst lamp possible. Of all the oxides which conduct electricity, but few are refractory enough for an efficient filament or glower. It was in determining the most desirable of these and in fixing the best proportions to use that Nernst did his greatest work in the development of the Nernst lamp. Ordinary red iron oxide, when formed into filaments and baked, will conduct electricity at ordinary temperatures, but such filaments do not withstand sufficiently high temperatures to be used as light sources. Magnesia and thoria, on the other hand, withstand exceedingly high temperatures, but these conduct electricity only with great difficulty. In general, mixtures of two or more oxides conduct better than a single oxide, and, in turn, the fusing point of the mixture is lower than that of either oxide alone. It seems that the vaporising point is not necessarily lowered, judging from the fact that thoria and the small amount of ceria used in a Welsbach mantle form quite a stable mixture, or possibly a chemical combination, while ceria alone or uncombined has a rather marked tendency to vaporise.

It would be a long story to take up the various properties of all the rare earth oxides and the possible combinations with one or more of the others. A mixture which is used largely in lamps of the Nernst type is composed of 85 per cent. zirconium oxide to 15 per cent. of yttria earths. Zirconium is not properly classified among the rare earths, though it is customary to do so. The term "yttria earths," as used here, means in reality a mixture of many oxides occurring together in certain minerals and closely allied in physical and chemical properties. Zirconia was used in comparatively large quantities for the first Welsbach mantles, and hence considerable attention had been given to various methods of producing it for such use. While many of the experimental glowers were made from zirconia brought from chemical supply houses, it was impossible to obtain uniform results from such material. Good zircon ore, which is a zirconium silicate, occurs in abundance in Henderson County, North Carolina, and this ore contains about 60 per cent. of zirconium as oxide. By treating this ore in the following manner quite uniform results are possible.

The ore is ground very fine in a ball mill and mixed with twice its weight of crude acid potassium fluoride. This is placed in an ordinary graphite crucible and heated slowly until thoroughly fused, and the ore is completely dissolved. The fused mass is then ground and dissolved in hot water containing a quantity of crude hydrofluoric acid equal to about one-tenth the weight of the fused mass. The silica remains undissolved as potassium silicofluoride (K_2SF_6), and the potassium zirconium fluoride (K_2ZF_6) is drained off while boiling hot into a silver-lined vessel. Upon cooling, the filtrate develops crystals of potassium zirconium fluoride, and, doubtless, small quantities of other elements in similar crystalline form. Iron and many other impurities which are present in the ore, or have been introduced by the use of the crude reagents, remain in the liquor which is drained from the crystals. The crystallising process may be much hastened by artificial cooling. Rinsing the crystals with cold water is likewise beneficial in removing all the mother-liquor. The crystals are gathered and

fused in a platinum dish. By this means any silica present seems to be vaporized, and other impurities, like titanium, are made insoluble. The fused mass is ground and dissolved in hot water, and crystallized as before. A few of the first crystals are removed, or, instead, alcohol may be added to the solution until a small amount of crystalline precipitate is formed. These first crystals contain much of the undesirable impurities. They are, therefore, removed and the crystallizing process is continued. The pure crystals are then dissolved in hot water, and the solution is made rather acid by the addition of pure hydrofluoric acid. Ammonia is now carefully added to the hot solution until a small amount of precipitate is formed. If the solution of the crystals has been been made acid, the addition of ammonia, even until alkaline, will precipitate iron and some other foreign metals, but will leave the zirconia in solution until it is cooled and diluted. This method was found to be an exceedingly simple one for removing iron from zirconia, which by other methods is a troublesome operation. The hot filtrate, after removing the precipitate of iron, is dropped directly into a cold ammonia solution, which at once precipitates zirconia as a hydroxide. Up to this stage of the process it has been necessary to use vessels and utensils not affected by hydrofluoric acid. The last precipitation may be made in glass or wooden receptacles. The precipitate is washed several times by decantation, and then pressed out on suction filters, and, after a thorough drying by heat, is powdered and sifted through fine bolting cloth, and is then ignited in a platinum dish with a very gradually increasing temperature and with constant stirring. The ignition process requires several hours, or sometimes days, the final temperature being a good red heat. Traces of silica are removed by this operation.

The physical condition of the precipitate is dependent to a great extent upon the amount of hydrofluoric acid in excess. When precipitated from an almost neutral solution, the precipitate dries into hard pieces translucent in appearance, and which are difficult to pulverize. With the greater excess of acid the material dries in lumps resembling starch, in which condition it is much more suited to our purpose. The zirconium made by this process seems to be reasonably pure. Special precautions must be taken to keep out dirt, and to that end it has been found advantageous to purify the air admitted to the rooms where the glower materials are prepared, by passing it through a water spray. An absolutely pure zirconia is not required, and though a trace of silica improves the efficiency and seems to diminish the initial depreciation of candle-power of a glower, it is a dangerous element to have present, for slightly more than a trace will cause a rapid change in potential difference at the glower terminals, besides causing a lack of uniformity in the behavior of the glowers of one batch, due to the fact that the silica becomes unevenly distributed among the glowers by vaporization and condensation occurring in a roasting process, which will be described later.

Although the purest materials make the best glowers for direct current, it cannot be said that an absolutely pure zirconia is desirable for alternating-current glowers; in fact, it seems that good alternating-current glowers require the presence of certain impurities, though in small amounts. Silica is particularly undesirable in direct-current glowers. In general, a glower which operates well on direct current, showing almost no change in potential difference, will show a greater change when operated upon an alternating-current circuit. The purity of the zirconia may be controlled to some extent by the number of times the material is crystallized during the purifying process, though each operation is attended with some loss of material. Physical properties are quite as important as chemical properties, and the procedure above described was evolved to give proper physical as well as chemical properties to the material. After all, the real test for the glower material lies in its ability to make good glowers. Test glowers have been made from hundreds of lots of zirconia, and these, together with careful chemical records of each lot, have been the guide in developing the chemical process necessary for the production of good glowers. For direct-current glowers a crystallizing process is also considerably used, but from a solution of zirconia in hot dilute hydrochloric acid. After two or three such crystallizations it is necessary to precipitate from a hydrochloric acid solution, as in the first process, to get the material into proper physical shape.

As to the yttria used, this is principally obtained from the minerals gadolinite or yttrialite. Gadolinite is found in Norway and Sweden, and also in Llano County, Texas. The Texas deposit seems to be confined in a very small district, and there is every evidence that it is the result of a volcanic eruption. It is found in crystalline form associated with yttrialite, cyrtolite, fergusonite, rowlandite, allanite, thorogumite, and other minerals. The ores from the Llano County district are radioactive, and the presence of a pocket in the surrounding quartz and feldspar is generally indicated by bluish discolorations radiating from the pocket through some distance into the surrounding matrix. It is also claimed that the ores, particularly the thorogumite, contain small quantities of confined helium gas. Gadolinite con-

tains, roughly, 42 to 45 per cent. of yttria earths, 23 per cent. of silica, 13 per cent. iron as oxide, and 9 to 12 per cent, of beryllia. Yttrialite contains 43 to 47 per cent. yttria earths, 30 per cent. silica, 5 to 6 per cent. ceria, didymia, and lanthan, as when as small percentages of urania. Fergusonite contains 32 to 42 per cent. yttria earths and 32 to 46 per cent. columbic oxide. Rowlandite contains 47 to 62 per cent. yttria earths, 26 per cent. silica, and small percentages of iron and magnesia. Allanite contains 20 per cent. ceria and didymia, with a small percentage of yttria earths and considerable percentages of iron, calcium, and aluminium.

It is a comparatively simple matter to obtain and purify the yttria earths from gadolinite and yttrialite so that they are suitable for glower making. About 1,000 grm. of ground ore are dissolved in crude aqua regia. The residue is filtered off and the solution evaporated to dryness, repeating this operation several times or until all the silica is removed. The neutral solution is then diluted to several litres, and the addition of a hot solution of oxalic acid to the hot solution containing the earths brings down the rare earths as oxalates, leaving iron and other impurities in solution. The oxalate is washed thoroughly with hot water and ignited, and the crude yttria earths are dissolved in dilute hydrochloric acid, just sufficient in amount to dissolve the oxide. To the rather dilute and neutral solution, which is cold, crystals of potassium sulphate are added in excess. After standing 24 hours the cerium group has been quite thoroughly separated as double sulphates and the filtrate is then treated with ammonia to bring down the hydroxides of the rare earths, thus freeing them of the great excess of potassium sulphate. The washed precipitate is dissolved in a quanitity of pure hydrochloric acid, just sufficient to dissolve it, and treated with boiling oxalic acid solution as before. This brings down the rare earth oxalates in sufficiently pure form. The oxalates are thoroughly washed with hot water and ignited, and any remaining potassium is separated from the ignited oxides by washing upon a filter with hot water. With the yttria, as well as the zirconia, physical properties are important, and the oxalate method gives an exceedingly fine precipitate which requires no mechanical treatment.

Experiments indicate that the yttria earths of the greatest atomic weights give the most satisfactory results in glowers. In other words, ytterbia is better than yttria. Owing, however, to the great difficulty of separating the yttria earths from each other, which is possible at present only by laborious fractionation processes, entailing great losses, not much has been done commercially toward using the higher atomic weight yttria earths beyond selecting ores which are rich in these earths. The Llano County ores seem to be superior in this respect to the foreign ores, the atomic weights being from yttrialite 115, rowlandite 107, fergusonite 103, and gadolinite 100, while the foreign ores may be as low as 90 or 92. The zirconia and yttria earths mixed in the proportions given above—namely, about 85 and 15, or 90 and 10, and about 5 per cent. of starch or gum tragacanth—are thoroughly mixed and kneaded into a hard dough and squirted by pressure through a die of proper size. This string, as it may be called, is dried and then broken into suitable lengths, which are roasted to an intense white heat in a platinum box. The pieces are then ready to have terminals placed upon them. A Nernst terminal is made by winding stranded platinum wire about the end of the stick of material and pasting over with a paste composed of ground glowers and zirconium chloride, thus forming a hard cement. The Hanks terminal has the platinum embedded in the glower material, the operation being carried on by the aid of an electric arc in which the glower material is fused.

It appears from extended tests that, with the zirconia and yttria mixtures, the Nernst terminal is not at all satisfactory for operation upon alternating-current circuits, considered commercially; and, likewise, the embedded terminal is equally unsatisfactory for operation upon direct-current circuits. It appears that for operation upon direct current that the oxygen liberated at the positive terminal must have free outlet from the terminal. Upon alternating current the reverse seems to be true; this statement being based in part upon the fact that the Nernst terminal operates more satisfactorily upon alternating current if it is carefully painted over a great number of times with a special glaze which covers the platinum wire entirely over with a dense non-porous coating. It appears certain that the mode of conducting the current is partly electrolytic in character. The specific resistance varies with the relative proportions of the constituents. In order to obtain glowers of the same specific resistance when using yttria earths of high atomic weights as when low atomic weight earths are used, it is necessary to have the presence of higher atomic weight materials in proportion to the atomic weights.

The accompanying curves (Fig. 1) showing the relation of starting temperature to percentage composition, are instructive in this connection. Ordinates to these curves represent temperature in degrees C., while the abscissæ show the varying proportions of yttria earths in the composition. It will be noticed that there is a well-defined composition of maximum conductivity in

each case, this maximum occurring at the higher percentage of yttria earths in the case of those glowers in which the earths of higher atomic weights are used. Also there is a distinct advantage in the use of the higher atomic weight yttria earths, in that the lowest starting temperature is obtained by the use of yttria earths of the higher atomic weights. Tests have also shown that at equal efficiencies, measured in watts per candle-power, the glowers made with the higher atomic weight yttria earths also have correspondingly longer life. Upon direct-current circuits the positive end of the glower generally runs much hotter than the negative end, and a black discoloration appears at the negative end, especially if impurities are present. In fact, this is one of the most certain indications of the presence of an impurity, especially silica. A glower operated in vacuum soon destroys the vacuum, probably due to oxygen gas liberated by electrolytic action. That all the current is carried by electrolytic means seems incredible, for the current carried per square unit of cross-section is far greater than can easily be accounted for by our usual conceptions of electrolytic laws. For example, upon direct current and calculated by electro-chemical equivalents the entire glower would be decomposed into its constituent elements in a very few minutes. Doubtless electrolytic decomposition and recombination do take place to a considerable extent, but is it possible to account for the entire transport of current in this way? The assumption that the current is all carried in this way seems unnecessary in view of what is known of the power of highly incandescent bodies to ionise air to render it conducting. The air in the neighborhood of a glower is conducting, and to such an extent that the leakage currents from glower to heater had to be reckoned with early in the experimental work, and the difficulty was obviated by the use of a double-pole cut-out which disconnected the heaters completely from electrical connection with the remainder of the lamp after the glowers started.

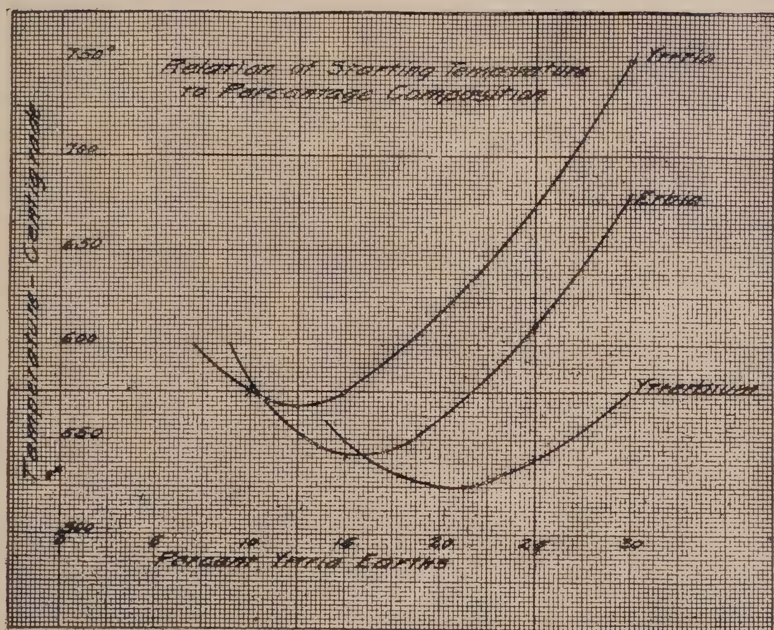


FIG. I.—RELATION OF STARTING TEMPERATURE TO PERCENTAGE COMPOSITION.

In connection with these speculations as to the real nature of the process by which the current traverses the glower, it is a fact that glowers which have operated for even a short time upon direct current will, when the current strength is diminished sufficiently to maintain the glower at only a good red heat, explode with considerable violence. The ionisation of the surrounding air at low temperatures is insufficient to conduct the current. The means of conducting the current then being largely electrolytic in character, the combination of the products of electrolytic decomposition cannot so readily take place, since the ions cannot so readily diffuse at the

lower temperature to recombine, and consequently disruption occurs. The suggestion that has so often been made—namely, that the current be reversed in direction at intervals, as, for instance, every time the lamp is started—is altogether impracticable for the reason that a grower once operated upon direct current must never have its poles reversed, for a reversal means almost instant disruption. The potential difference across the terminals of the glower immediately after such a reversal is much lower, indicating something analogous to polarization effects as we know them in aqueous electrolytes.

In general with the Nernst terminal, the potential difference across the glower at the normal current value is the same with alternating or direct current. With the Hanks terminal, or embedded type, the potential difference with direct current may be as much as 20 volts lower. The life of the alternating-current glowers is almost directly proportional to the frequency at the commercial frequencies from 25 to 133 cycles per second, again suggesting electrolytic conductivity—at least, in part. Some tests are now being made to determine the behavior of such glowers when operated at much higher frequencies. It would seem that electrolytic decomposition should almost, if not entirely, disappear at the higher frequencies, in which case there is the possibility of satisfactorily operating the glowers in vacuum, resulting in a decidedly better efficiency, perhaps twice what is now attained in the Nernst lamp. Operated in vacuum, a blue aurora, or luminous haze, surrounds the glower operated either upon direct of alternating current, and this has been thought to be due in some way to (zirconium or yttrium) recombining with the slight amount of oxygen liberated. This idea seems plausible from the fact that objects such as wire or glass near the glower become coated with a white deposit of the glower oxides in a comparatively short time, and the resistance of the glower increases rapidly. It would seem that oxygen necessarily plays a part in conducting the current, for a glower in an atmosphere of hydrogen or nitrogen behaves similarly to the one operated in vacuum. In carbon monoxide or dioxide the glower exhibits the same characteristics as in air. The glower operated in vacuum exhibits a peculiar sluggishness in responding to changes in voltage at its terminals. The small glowers, up to 0.5 ampere, are made solid in cross-section, the larger ones are generally made tubular, and, in fact, one-ampere glowers must be made so. The reason for this is not that greater efficiency is sought by increasing the ratio of surface to volume (which is, of course, a fallacy), but inasmuch as the glower possesses a decided negative temperature coefficient with respect to electrical conductivity, the center of a large solid glower would become molten before the outside surface reached an efficient temperature, the center being the better conductor. Glowers which have been greatly overrun often exhibit this truth by the appearance of a nodule of molten material which has spurted out to the surface. The decided negative temperature coefficient is well illustrated by the fact that a thin flat strip of the glower material, provided with the proper terminals, will conduct current along one edge while the remaining parts are comparatively cool and non-conducting. A commercial glower must operate at a high temperature in order to be efficient. Nernst glowers operate at about 2,300 deg. C., it is supposed from determinations made by photometric means, and at about twice the efficiency of a carbon incandescent lamp. The spectrum of a glower is a continuous one, and no evidences of selective emission are noted in any particular region of the visible spectrum.

During the life of the glower, which averages about 800 hours under normal conditions of manufacture and voltage regulation, a depreciation of candle-power takes place, due to a number of causes. In the first place, all oxides of the rare earths do depreciate rather rapidly in light intensity per unit of surface at any given temperature. This is true whether heated by gas or electricity, and a platinum plate coated on one side with rare earths and heated from the rear by an oxyhydrogen flame behaves similarly. It is an inherent property of these oxides, and a depreciation of 10 or 20 per cent. may occur during the first hour. There is then a slow diminution of intensity of light, also inherent, and seemingly accompanying the tendency of the glower to change from an amorphous to a crystalline structure. A rise of potential difference across the glower terminals is usual, though it is possible to counteract this tendency, at least, in part. The effect of a rise in potential difference, obviously, is to diminish the intensity of light by permitting less current to traverse the glower running on a current-potential circuit. With carbon incandescent lamps the useful life or "smashing point" is considered to be that number of lamp hours during which the candle-power decreases 20 per cent. from the initial candle-power. Nernst lamps are similarly rated, counting as initial candle-power that measured after the initial decrease above mentioned. Another cause of the depreciation in candle-power is blackening of the enclosing glassware and reflecting surfaces. In this connection the blackening is due largely to platinum which has been vaporized and deposited upon these surfaces. It has been found that the purest platinum is far better than that containing iridium or others

of the platinum group, since pure platinum vaporizes much more slowly than alloys with these other metals. To produce uniform chemicals and glowers in which the tendency to depreciate in light intensity and to increase in potential difference shall be a minimum makes the problem intricate and fascinating, and still worthy of much study and investigation.

Curiously enough, not the least of the problems to be solved in the development of the Nernst lamp was to overcome the tendency of porcelains to conduct electricity, the very property which in the case of the rare earths made such a lamp as the Nernst possible. A heater is necessary to start the glower. The heater is made by winding fine platinum wire upon a porcelain tube. It was necessary to produce a suitable porcelain which would withstand the high temperature required and, at the same time, not conduct electricity. A porcelain composed of kaolin, alumina, and silica is sufficiently refractory and porous to withstand the heat, and is an almost perfect non-conductor at high temperature. The porcelain piece upon which the glowers and heaters are mounted is also of the same composition. Another form of heater, used more abroad than in this country, is helical in shape, and the glower is mounted in its axis. This is made of pure kaolin, and after squirting into tubes about a millimetre in diameter, winding with fine platinum wire and covering over the wire with paste, the small tube is bent into a helix upon a mandrel, a pointed blow-pipe flame playing upon the kaolin tube at the point where it bends on to the mandrel.

As to the possibilities of self-starting filaments, many oxides will conduct at room temperature. A mixture of iron and tin oxides, about 70 iron to 30 tin, will start without preliminary heating and withstand rather a high temperature. There are many other smaller combinations; likewise other possibilities exist, such as carbides, silicides, and borides, operated either in vacuum or gases. A Nernst glower may be made to conduct the current at low temperatures by running it for a short time in a rarefied atmosphere containing a carbon gas. If to a globe in which a glower is operating in a good vacuum an amount of hydrocarbon gas is admitted sufficient to lower the vacuum even less than a millimeter, the potential difference across the terminals of the glower will decrease rather rapidly, and in the interval of a few minutes, or even seconds, and the glower will have become a conductor when cold, or, in other words, self-starting.

The following experiment was tried: A glower was mounted in a glass bulb and in the axis of a carbon filament of helical shape. The bulb was well exhausted and sealed off. The carbon filament was used four or five times to start the glower, alternating current being employed. After the glower had run a few hours it was noted that it was changing color at its terminals. The dark discoloration gradually crept toward the middle, and after about 24 hours the glower could be started without preliminary heating. Apparently enough of the carbon filament was oxidized during the short time it was in use to give a slight quantity of free carbon monoxide in the bulb, the source of oxygen being the glower itself. It is uncertain whether this gas was effective in reducing some of the glower material to its metallic form, or whether a conducting carbide was formed by the action of the carbon gas upon the glower materials. The former explanation seems preferable, for the reason that it was noticed that the darkened portion at the negative end of direct-current glowers is of higher conductivity than the glower proper, and it seems quite likely that this deposit is a metal separated out by electrolytic action. Metallic zirconium, for example, withstands very high temperatures in the open air without oxidizing, and its melting and vaporizing points where air is excluded must be very high.

Many possibilities exist such as are suggested by the above experiments, and many of them have been tried. Boron carbide, for example, withstands very high temperatures and is a conductor while cold, though it seems to vaporize somewhat too rapidly—at least, this is the case with samples tried, which probably were not very pure. A Nernst glower, as well as those composed of thoria, mangnesia, and almost any of the refractory oxides, may be made conducting by treatment with a hydrocarbon gas. Sodium and potassium vapors also effect a reduction to the self-starting condution, though not generally so readily as carbon.

There is a broad field open and much that is not known of the properties of the rare metals. Oftener than not the supposedly pure metal is impure, and the properties generally ascribed to it are in reality those of its carbide or other little known combination. Note the difference in properties of pure iron and iron containing even less than 1 per cent. of carbon. Is it not a fact, then, that almost nothing is known of the physical properties of the rare metals. A good example of this point, and one bearing directly on our subject, is the recently developed tantalum lamp, the filament of which is a fine thread of tantalum metal. Tantalum metal, until recently, was not known to possess properties which now make it a promising addition to electric illuminants. More or less experimental work has been done, particularly in Europe, in using the rare earths

in electric arcs with the idea of obtaining better efficiency and more pleasing light. Arc lamps have even been tried with electrodes composed entirely of the rare earth oxides, though at the present time the greatest advances in arc lighting are being made along the lines of introducing such elements as boron and titanium into the electrodes.

In conclusion, your attention is directed to a set of curves (Fig. 2) which has been plotted to show the relation between the temperature and the energy radiated in the various wave-lengths of light for incandescent black bodies. Various temperatures are assumed, and curves calculated, showing the energy radiated at each wave-length. The visible spectrum is defined by the vertical broken lines marked red and blue. The exceedingly small proportion of the total energy which is radiated within the limit of the visible spectrum even at a temperature as high as 3,500 deg. C. is startling enough. We are, apparently, at the present only on the border of the possibilities.

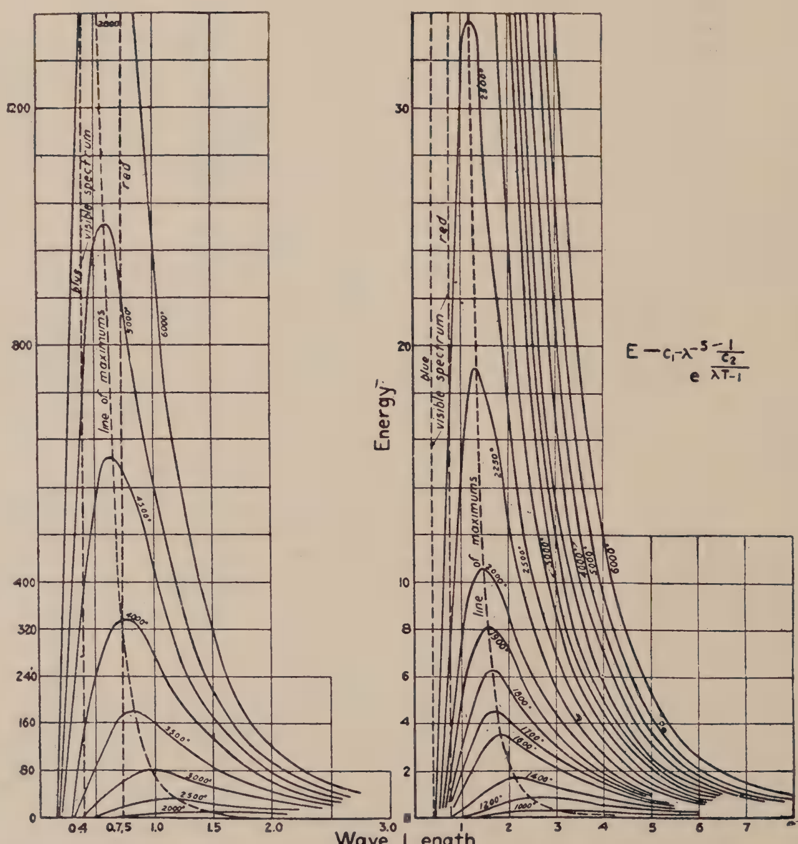


FIG. 2.—CURVES SHOWING RELATION BETWEEN THE TEMPERATURE AND THE ENERGY RADIATED IN THE VARIOUS WAVE-LENGTHS OF LIGHT FOR INCANDESCENT BLACK BODIES.

FOREIGN ITEMS

SOME INCANDESCENT ACETYLENE BURNERS

Their Behavior and Illuminating Power

By F. H. Leeds, F.I.C.

Journal of Gas Lighting (London), June 19, 1906.

Soon after the more pressing difficulties in the generation of acetylene from calcium carbide were overcome, and the modern self-luminous burner based on the Dolan principle was manufactured satisfactorily, several inventors turned their attention to the construction of an incandescent burner for the gas.

Although the acetylene prepared in a well-designed plant is a most excellent illuminant when consumed in ordinary burners, and may be said to be almost without any successful rival in places where a supply of cheap gas cannot be obtained, members of the industry have naturally desired to render the light of acetylene still cheaper than it is at present; and therefore the various attempts made to construct a good incandescent burner have been watched with some interest. Of course, in the case of so intrinsically powerful an illuminant as acetylene, the advantages of burning it under a mantle are relatively less marked than in the case of coal gas; for taking common burners of ordinary domestic size and run at usual pressures, coal gas will emit (say) nine times as much light under a mantle as in an open flame, whereas the corresponding proportion with acetylene is more nearly as three to one. Again, the light given by acetylene in luminous burners is so brilliant and steady, and of such a pleasing tint, that it seems a pity in ordinary circumstances to forego the advantage of having no mantle to look after. Nevertheless, power to treble the light obtained from a unit volume of gas is not to be despised, unless an adoption of the incandescent system of combustion should introduce overwhelmingly serious defects or inconveniences.

A few of the incandescent burners constructed several years ago worked fairly well when tested by the present writer; but from information given by him, it appeared that other samples behaved most indifferently. There were two or three causes for this. The burners, it was stated afterwards, were sent out by their makers without having been individually tested; and since the injector jets of burners passing only 10 to 15 liters per hour are very small, and have to be drilled most accurately, it is hardly surprising that the judgments passed on different specimens should vary. Secondly, there was a difficulty in obtaining suitable mantles for the burners—in this country, at all events. The mantles supplied by the burner makers lasted well enough (under proper conditions); but when they failed, only small Kern mantles could be procured here, and the latter were neither of the proper shape nor of sufficient strength to withstand the very high temperature of the acetylene flame. The third (and probably most important) reason why these earlier incandescent burners proved generally unsatisfactory, lay in the nature of the gas they had to consume. Even a few years ago the quality of the acetylene issuing from the average generating plant varied very considerably from time to time. When the generator was first charged, the gas contained much air; but the proportion fell to practically nothing before the carbide was entirely exhausted. The upper explosive limit of mixtures of acetylene and air is, however, so high that an incandescent burner will not bear an appreciable or variable quantity of air in the gas without exhibiting a tendency to fire-back with a sufficiently powerful shock to injure the mantle. The gas also usually contained its full complement of "carbide impurities," and was frequently heavily loaded with "generator impurities." A normal amount of phosphorus in the former is fatal to a mantle in 100 hours or less; and the lime-dust of the latter chokes the burner jet or gauzes. It has also been stated that moisture in the acetylene is harmful; but no evidence of this has been obtained in the writer's experiments, where the gas was always naturally loaded, and presumably saturated with water vapor at the temperature at which it passed through the wet meter that was always used whether the burners were being tested on the photometer or not. A minor obstacle to the successful behavior of these original incandescent burners depended on the irregular pressure thrown by many of the generating appliances sold; the displacement holders being frequently fitted without any trustworthy governing device to neutralize the effects of differences in the water-level.

Among the 92 German villages now provided with public acetylene supplies, nearly all the plants that have been erected within the past two years or so feed street-lamps fitted with incandescent burners, and a large proportion of the private lights in use are also stated to be incandescents. Most

of the burners are said to be of a certain make, a specimen of which is in the writer's possession. This particular burner has worked well; but the mantles supplied with it have left something to be desired in illuminating duty, owing probably to an imperfect fit. Still, it is only right to say that reports coming from the German villages about the burner in question are mostly favorable. Another incandescent burner has been recently designed by Schimek, and is made by Güntner, of Vienna, in different sizes having nominal consumptions of 5 liters per hour and upwards. This is the type of burner that has been examined and tested most thoroughly.

THE SCHIMEK BURNER.

The Schimek incandescent acetylene burner is constructed in three main portions. The lowest has an internal thread for attachment to the bracket or pendant, two male threads on its upper part, and a female thread at the top, into which the jet itself is permanently screwed. Internally it is provided with a fine gauze of brass wire and a plug of cotton wool or the like to extract any dust from the gas. The middle main portion of the burner is the bunsen tube—parallel outside, but slightly tapered internally to a double truncated cone. The lower part is expanded into a mushroom head with a perforated base; and the central orifice in the latter screws upon the small upper male thread of the jet portion. The lower male thread of the jet portion supports a flat brass disc, which can be screwed upwards till it touches the base of the mushroom, or screwed down to leave an open space all round. The primary air enters between the upper surface of the disc and the bottom of the mushroom; and its volume is therefore under control in the same fashion as the air supply of the new standard coal-gas argand. The uppermost portion of the burner resembles the upper part of a "C" burner, but has a circular flame orifice, and an eccentric mantle rod. In putting the burner together, the bunsen tube and the jet portion are screwed up tightly; but the disc is left finger-loose. The lower edge of the mushroom or cone has half-a-dozen small notches cut in it; so that if the disc is run up to its highest position, some air still enters the mixing-tube. Indeed, the burner can be used temporarily without a mantle, by raising the disc as described. It then gives a round stumpy self-luminous flame, which does not smoke. When employed properly as an incandescent, the disc is lowered to its full extent. The mantles supplied with these burners are stated to be burnt-off and formed on a blowpipe fed with acetylene and air.

The nominal 10-liter burner in the writer's possession was erected with its own chimney upon a cheap, shaky coal-gas bracket in an exceptionally dusty room, and was fitted with a hemispherical cup and conical shade of opal glass taken from a gas argand. At pressures ranging (intentionally) between 3.8 and 4.3 inches, the burner was run for periods seldom exceeding two hours at a time from the beginning of last November to the middle of February, with one mantle only ("A 10"), when an accident happened in moving it. The light was about 3 feet above the level of the writer's desk, close to an inverted "Bijou" coal-gas burner; the two lights being employed (although that of the acetylene was the more powerful) indifferently for all purposes. The acetylene consumed was crude for a few hours, purified with "frankoline" most of the time, and "dissolved" for the remainder. At the time of the accident to the mantle, it had been noted to have been burning for 150 hours; but as it had been constantly lighted for a few minutes only to exhibit it, and to test its power of resisting ordinary treatment, the mantle had really been in use much longer.

The behavior of both burner and mantle was entirely satisfactory, and the light was always excellent. Whether the burner cock was turned slowly or quickly, the flame lighted or went out smoothly; the small explosions observed with certatn earlier specimen burners being absent. When the gas contained a little air, the burner lighted with a series of jumps; but they did no harm to the mantle. The occasional presence of air in the acetylene was due to the cock being on the wall end of the bracket; whereas for all small incandescent burners its proper position is as close to the jet as possible. On two or three occasions, the burner was alight for five or six hours during a bad black London fog; but it seemed to need less cleaning afterwards than the coal-gas incandescents elsewhere.

As an experiment, the burner had been lighted several times when the mantle was still in its proper position, with the regulating-disc screwed hard-up against the cone. This caused the flame to smoke freely, and to coat the mantle with soot. The formation of soot in such unfair conditions is inevitable, because the presence of the mantle round the flame interferes with the secondary supply of air which would otherwise reach it. As mentioned already, if it be desired to employ the incandescent burner for a short time as a self-luminous one, the mantle must be taken off. Nevertheless, in spite of the copious deposition of carbon upon the mantle, the soot burnt away in a few minutes when the air supply was increased again to its normal amount, and no signs of injury were ever apparent upon the mantle. At the time of its collapse, indeed, the mantle was in no worse condition than that of a coal-gas mantle of equal age.

Since these lines were written, it has been asserted that the failure of a mantle fitted upon an incandescent acetylene burner causes every object in the room to be covered with soot. The statement appears improbable on the face of it, because inside the mantle the flame is atmospheric or non-luminous, and when the mantle fails, the flame only receives an additional supply of air from round its base and edges. As a matter of fact, no such production of free carbon has ever been noticed by the writer—except, as already stated, when the adjustment of the burner was wilfully interfered with for experimental purposes. The chimney of his experimental burner is only 2 ft. 6 in. from the ceiling; but no mark or appreciable degradation of tint has appeared thereon. Indeed, it is nearly two years since the ceiling was "whitewashed," and there is no reason yet apparent for having this unpleasant domestic operation repeated. A second mantle has, of course, been alight on the same burner for many hours since that quoted as "A 10" succumbed to a hurried transference.

Through lack of opportunity, the precise emissivity of the "A 10" mantle was not tested when it was new; but after being alight for 32 hours at a pressure never exceeding 4.2 inches, it showed a duty of 98.2 horizontal candle-power per cubic foot, and when it was known to be 150 hours old (really much older) its duty was 82.9 candle-power. So far as could be judged from the other mantles which were employed for photometric purposes only, mantle "A 10" was a perfectly fair average specimen.

THE GENERATING PLANT.

The generator of the plant in which the acetylene consumed on the photometer was evolved, belongs to the carbide-to-water pattern. After bubbling through the lime-water of the decomposing vessel, the gas passes in fine streams through a washer, and then enters a small rising holder. From the holder, it passes through or past a purifier, having to force its way through 7 inches or less of material. When the material is "frankoline," the acetylene next passes through a layer of cotton wool; then through several inches of quicklime in small fragments; and finally through some inches of cotton wool again. From the purifier, the acetylene travels to a regulating cock with slotted plug, and then to the meter. At the meter outlet is a needle-valve, a pressure gauge, a large empty jacketed glass vessel (which acts as a pressure equalizer), and another stopcock with slotted plug. Here the gas-pipe branches —one limb leading to a bracket where the gas stored can be burnt off, and the other terminating in the cap-and-liner of a union. The meter employed passes 0.1 foot per revolution; the accuracy of its water level being periodically checked by graduations on the holder bell. The latter was graduated by pouring weighed quantities of water into it when inverted, a vertical height of about one-eighth of an inch being equal to 0.01 foot. The liquid in both meter and holder is pure tap water; but it was charged with acetylene by being in use for some months before the photmetric work was commenced. When tests are made with dissolved acetylene, the cylinder is connected to a separate inlet into the holder—the by-pass on the purifier being opened; and in all cases the holder is filled with gas before making photometric readings, the generator or the cylinder being shut off. The precise working pressure is obtained by loading the bell (if necessary) when the burner is alight and all cocks are wide open, until the pressure thrown is about 0.2 inch above that desired. This is reduced to 0.1 inch above that required by moving the lever handle of the first slotted cock at the meter inlet, and finally set exactly with the needle-valve at the meter outlet. The numerous single figures for the burner consumptions obtained during the work showed that the pressure remained absolutely constant, whether the holder bell was nearly high or nearly low. When the generated acetylene burnt on the photometer was supposed to be purified, periodical tests with Keppeler papers were made to see that the material was still acting efficiently.

PHOTOMETRIC OBSERVATIONS.

Not much need be said about the method employed in measuring the light afforded by the incandescent acetylene burners under consideration. The standard light was a Harcourt pentane lamp. Only horizontal candle-power has yet been determined. Ten observations were made in each test—one every minute in the case of the large burners, and one every second minute when the burners were so small that the meter would not otherwise complete an entire revolution during the test. In the earlier portion of the work, five readings in each test were made by each of two observers; but afterwards each observer made his own complete set of ten readings. The figures recorded below are, therefore, the mean result of the two sets of ten readings each.

THE RESULTS OBTAINED.

The results obtained with the Schimek acetylene burners are given below. They are not as exhaustive as might be wished, owing to the limited supply of mantles in the writer's possession, and to the fact that the standard emissivity of the mantles is seriously increased by running them, even for a short time, at an abnormally high pressure. The probability of so great a change in this respect was not contemplated when the work was begun; and therefore

some particular mantles were, for the sake of convenience, tested with dissolved acetylene at 4.5 and 5 inches of pressure before they were tried with ordinary acetylene at 4 inches. In consequence, their duties were raised by 20 or 25 per cent., as will appear immediately. In the following tables, the individual mantles are referred to as "A," "B," etc.; the figures "10" and "15" referring simply to the corresponding burner sizes. Except where otherwise stated, the mantles were only alight for an hour or so before the first test, and for ten or fifteen minutes between each subsequent one.

TABLE I.—NOMINAL 10-LITER BURNER.
[Purified Acetylene. Mantle "B 10." Light measured through chimney.]

Pressure. Inches.	Consumption. Cubic Foot per Hour.	Candle-power.	Duty.
4.0	0.470	42.3	90.0
4.0	0.478	46.0	96.2
4.0	0.474	45.2	95.4
4.0	0.470	45.8	97.4
4.0	0.467	47.0	100.5
4.5	0.498	52.8	105.0
4.5	0.499	53.8	107.8
5.0	0.528	60.0	113.7

It seems perfectly fair to reject the first of these tests at 4 inches pressure, on the ground that the mantle had not shrunk to its normal proper shape. Accordingly, the following are the average normal results:

Pressure. Inches.	Consumption. Cubic Foot.	Consumption. Liters.	Candle-power.	Candles per Cubic Foot. Duty.
4.0	0.472	13.35	46.0	97.4
4.5	0.498	14.10	53.3	106.4
5.0	0.528	14.95	60.0	113.7

TABLE II.—NOMINAL 15-LITER BURNER.
[Purified Acetylene. Mantle "C 15."]

Pressure. Inches.	Consumption. Cubic Foot per Hour.	Candle-power.	Duty.
4.0	0.660	67.5	102.3
4.0	0.662	71.3	107.7
4.0	0.664	70.6	106.3
4.0	0.665	70.4	105.8

This mantle was not tested at any pres- for other purposes. The period through sure higher than 4 inches—being required which it was alight before the completion of the first test was so long in comparison with the intervals between each succeeding examination that there seems no good reason for rejecting the first observations recorded, and therefore the mean normal results are as follows:—

Pressure. Inches.	Consumption. Cubic Foot.	Consumption. Liters.	Candle-power.	Candles per Cubic Foot. Duty.
4.0	0.663	18.8	70.0	105.5

Thus it is clear that a duty of 100-candle-power per cubic foot can easily be obtained from even small incandescent acetylene burners when run at the lowest pressure for which they are intended by their makers. The precise duty appears to increase somewhat as the size of the burner increases, and more conspicuously as the working pressure is raised. This might, of course, be expected. Representative figures as to the manner in which the mantles decrease in emissivity with age cannot be given, because mantle "A 10," already described, was not tested when new. Assuming, however, it had the same original illuminating power at 4 inches as mantle "B 10," its original illuminating power after being run for a short time at a pressure up to 4.3 inches should have been somewhere about the mean between 97.4 and 106.4, or 10-candle-power per foot. On this basis, it may be said to have lost 3.6 per cent. of its emissivity in 32 hours, and 18.7 per cent. in 150 hours. But this assertion is made with all reserve, for manifest reasons.

THE DEMERITS OF ACETYLENE FOR LIGHTING

By HORACE ALLEN.

The Electrical Review (London), June 8, 1906.

Though the demand for acetylene gas has steadily and continually increased ever since calcic carbide became a commercial commodity less than fourteen years ago, through the development of the electric furnace, it is doubtful whether it will ever seriously enter into competition with either coal gas or electricity in the field of general and economical illumination for public or domestic purposes, or for power development. This is partly accounted for by the cost of calcic carbide, for even with electric current at 13d. per unit the cost of manufacture and materials amounts to

from £9 to £10 per ton at the furnace. The chief item being for current, the possibilities in the way of the price ever coming within the range of competition are very remote as long as electricity is employed in the manufacture. Added to the cost of manufacture, there is necessitated the expense of packing in hermetically sealed drums and tin canisters, owing to the great affinity of calcic carbide for moisture.

Pure acetylene gas is credited with having a *faint, sweet smell,* but the smell given off by all the carbide the writer has had the opportunity of examining has been quite the reverse of either faint or sweet.

The unpleasant odor arising from raw carbide upon opening the receptacle is a primary source of objection, and any neglect in the way of resealing the drum after the withdrawal of the required quantity, results in the continued gradual generation of acetylene and its objectionable smell. For this reason the best place to store carbide is at some considerable distance from any occupied building.

Various methods have been applied to overcome this serious drawback in the way of coating the carbide, and by counteracting the smell by the application of strong, sweeter smelling essences. However, such treatment has chiefly been confined to small retail parcels, for which a higher price has to be charged to cover the additional treatment.

The method of dipping the carbide into petroleum, and then into glucose, resulted in a material that was almost entirely protected from the atmosphere and free from any objectionable odor, besides having the further advantage of being much more slowly acted upon by water.

However, even this treatment does not entirely remove the tendency to continue the evolution of acetylene gas after the consumption has ceased, a very serious source of trouble in all generators using raw, or untreated, carbide. Another feature in connection with the action of carbide and water in the generation of acetylene is the amount of heat given off in the reaction.

One pound of carbide, when brought into contact with water, gives off in its decomposition 753 B. Th. U., which, in the absence of an excess of water, is sufficient to raise the temperature of the surrounding materials to a bright red heat. On this account, all apparatus for the generation of acetylene which is not provided with a sufficient quantity of water to ensure the dissipation of the heat evolved, is liable to become heated to a dangerous point in case of too rapid a consumption of gas. When this happens, the acetylene becomes decomposed, as is evident by the black material in the residual lime.

To a certain extent, calcic carbide resembles the electric accumulator or storage battery, for while by present processes it requires the expenditure of from 2.0 to 2.3 h.-p.-hours to produce 1 lb. of carbide, this may be conveyed to any distance, or stored for any length of time, if properly protected, and then the acetylene generated from it is capable of developing 1 h.-p. for one hour if used for driving a gas engine; this, by the way, is not a demerit, but the reverse.

By virtue of this property, it can be used to transfer energy from waterfalls in distant situations to localities where it could be turned to useful account.

The residual lime remaining from the decomposition of calcic carbide in the generation of acetylene has a very unpleasant smell when first brought out of the generator—so much so that, in the case of small apparatus, it is offensive if brought anywhere near inhabited rooms. The sludge settles down into a more or less solid mass if left to accumlate, and is somewhat difficult of removal, though it is claimed that when the carbide has been coated with glucose the lime is chiefly rendered soluble; this claim is generally more theoretical than actual, owing to the small proportion of glucose employed.

To turn our attention now to acetylene, there is no doubt that the light is of high quality, both in regard to illuminating power and its preserving the natural colors of materials, etc.

A drawback which has given considerable trouble is the necessity for a very fine orifice in the burner; it took a considerable period of time for the devising of a suitable burner, but even now, while the jet is of such small dimensions, it is liable to be stopped by the slightest particle of dust, or, on the other hand, carbon becomes deposited and a heavy smoky flame results.

To prevent the deposit of carbon at the orifice of issue from burners, a very common source of trouble, the device of providing duplicate orifices at such an angle that the two issuing jets are made to impinge upon each other and form a clear flat flame, was claimed to be successful.

This class of burner found much favor as an improvement over the single jet, but it not unfrequently happens that some slight particle of dust lodges in one of the jets, and deflects the flow of gas to such an extent as to prevent the two jets meeting centrally; the result is a very unsatisfactory flame, which can only be rectified by inserting a fine needle or wire into the clogged orifice. This would seem to be a very simple matter, but it must be borne in mind that the burner goes wrong just when the light is required, and it is necessary for the acetylene gas tap to be closed and some other light obtained to enable the clearing of the burner to be effected, owing to the minuteness of the hole in the burner and its angular direction; to insert

the wire in the orifice in most burners is quite on a par with threading a needle with the eye in a rather inaccessible position.

Some burners have the orifices in such a position as to render it a very delicate matter to clear them on their becoming clogged, but the simplest way to overcome the trouble is to provide spare burners, it being an easier matter to change the burner than to probe it *in situ*.

While ordinary coal gas, in course of time, reduces leakage, through deposit, this is not the case with acetylene, so that all joints must be thoroughly sound from the first.

In regard to leakage, the unpleasant distinctive odor of impure acetylene had the advantage of quickly indicating the existence of a leak and its locality. When the gas is purified properly there is less evidence, and therefore greater danger, from this source of trouble.

Owing to its high specific gravity, 0.9, or twice that of coal gas, it does not so readily diffuse and pass away; and although the smallness of the jets renders the volume passing out in a given time considerably less than in the case of a coal gas burner, though it must be borne in mind that the pressure is usually about twice that required for coal gas, the escaping gas hangs round and tends to form an explosive mixture which would do considerable damage if even a soldering bit or glowing cigarette should be brought near, the ignition point being only 896° F., while so small a proportion of acetylene as 3.5 per cent. forms an explosive compound with air, as compared with 6 per cent. with coal gas.

It is claimed for acetylene that its vitiating effects are only about one-eighth those of coal gas flame, and that its heating property is very slight, but it must be remembered that the heat given off by an ordinary gas flame or incandescent burner has a great ventilating effect, so that the impurities given off will also be carried away as long as there is an outlet.

A NEW ELECTRIC ARC LAMP OF HIGH ILLUMINATING POWER, USING SECONDARY CONDUCTORS IN THE ARC

By E. Stadelmann-Nehein.

Electrotechnische Zeitschrift.

That in recent times attention has been given to increasing the production of light with electric lamps is shown by the introduction of the flaming carbon arc lamp, and also the Nernst lamp. Not alone for incandescent lamps are secondary conductors available for securing the largest amount of light, but also may be turned to account for arc lamps. Such lamps, however, have never become popular, although different methods of construction have been used; for example, lamps with an arc between secondary conductors, lamps with the shell pushed over the arc of the secondary conductor, and those in which the secondary conductor is put between the carbons in the path of the arc itself. The attempt has also been made to introduce incandescent bodies in this way.

The attempt to increase light production by means of secondary conductors is not new. More than fifty years ago Staite utilized the radiation of a heated secondary conductor in the construction of an electric lamp; and the Soleile lamps of De Laye may be put in this class. In both, the secondary conductors are used both for producing and reflecting light. Two lamps, the Jabbockoff candle (1876) and the Soleil lamp of Clerc and Bureau (1879), have been known for some time. The first depended principally upon the volatilization of the secondary conductor, which was placed between the carbons, for its strongest light. An obstacle to its general use was its short life and the fact that it had to be relit after having once been extinguished; the latter disadvantage was possessed by the Soleil lamp also; which, however, had the advantage over the electric candle in that the secondary conductor served as a condenser and reflector of light, which produced a quiet and steady illumination. Neither lamp had mechanical adjustment; the burning away of the carbons, and in the case of the candle, of the secondary conductor as well, were the only means of regulation. All of these older lamps had the objection that the carbon was in close contact with the secondary conductor, and the Soleil lamp had the further disadvantage that the rays from the carbon itself were entirely absorbed by the projecting blocks of stone, so that the only light the lamp produced was that from the incandescent marble.

If we utilize the advantages of the above named lamps, and avoid their disadvantages, we secure an arrangement of arc lamps using a secondary conductor as a light condenser and reflector in which the light produced by the carbon and of the arc itself, as well as the rays from the incandescent secondary conductor and the light which this reflects, can be utilized, thus securing the greatest possible gain in illumination. Such an arrangement consists of one or several carbon rods, B, B, of round, prismatic, or flat form, which are at a certain distance from one or several parts of a secondary conductor (see diagram). Lighting the lamp is accomplished by causing the carbons to approach as in the ordinary arc lamp. When the circuit is closed the carbons are separated a sufficient

distance by any suitable mechanical arrangement, to produce a steady arc. The secondary conductor is then heated by the arc until it becomes incandescent and consequently a conductor, when the distance between the electrodes can be increased. Separation from the secondary conductor can then be so regulated that the resistance of the arc between the electrode and the conductor does not become so great as to render the arc unsteady. By separating the electrodes from the secondary conductor they are prevented from fusing together. A part of the current flowing between the electrodes passes through the incandescent secondary conductor, while the balance passes between the electrodes through the air, the arc lying close to the secondary conductor. The branching of the current between the electrodes is shown in Fig. 1.

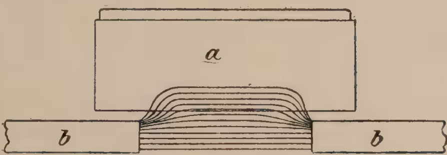


FIG. 1.

By this arrangement light is produced at the same time from the electrodes, the arc, the incandescent secondary conductor, and by the rays reflected therefrom. The light of a lamp constructed on this plan is exceedingly steady. Even the presence of air currents is absorbed in part by the secondary conductor, which renders flickering impossible. When the secondary conductor is incandescent and therefore conveying current, the arc is attracted by it and in a way adheres to it. Variations of current will not produce variations of light, since the secondary conductor is a good light accumulator, and always gives a large part of the total light given out, so that variations will only produce small changes in comparison with the total amount of light. In this respect the arrangement mentioned is similar to the Soleil lamp.

Compared with the Soleil lamp, the arrangement described has the further advantage of a larger production of light, since there is considerably less cooling off than with the large stone blocks of the Soleil lamp, and also since not only the secondary conductor and a part of the arc, but also the glowing electrodes and the entire arc are utilized. It is best to use for the secondary conductor a material that volatilizes as little as possible and gives light only by being highly heated. This produces a considerably quieter and more even light, the lamp also working more economically, as the secondary conductors do not need to be replaced so often. The arrangement has the further advantage of having the principal distribution of light downward, which is desirable for general illumination; but the arrangement may be rotated, and the longer axis of the electrodes be so arranged that the light could be thrown in any desired direction.

Experience has shown that chamotte is a material which holds well in the arc in that it did not form drops, although it became soft; but further experiments may develop some still more suitable material which would be still more resistant and give more light. In this arrangement the lamp would have the electrodes in a horizontal position, which would be especially suitable for lower rooms, but could also be used for higher rooms. By this we do not mean to say that this form must be used for such cases, but they can be constructed to correspond nearly to the usual form of arc lamps, in which case the electrodes would have to be arranged at right angles to each other, and the secondary conductor having a corresponding form, which would have to be put into the lamp in such a way as to be replaceable as well as the carbon.

Owing to lack of time measurements could not be made, but the experiments have shown the advisability of further work in this direction and this description should lead to such further experiments.

In conclusion, the use of a secondary conductor of a high fusing point so arranged with reference to the arc as to do away with the fusing together of the secondary conductor and the electrodes as well as the disintegration of the secondary conductor by the arc by separating the electrode from the secondary conductor has proven that the glowing ends of the carbons, the arc, and the conductor all serve as light-sources, while the latter also acts as a current guide, light reflector and condenser, and thus serves as a means of steadying the light-source.

STREET LIGHTING

By C. Turnbull.

The Electrical Review (London), June 8, 1906.

The recent opposition of the L.G.B. to loans for electric street lighting makes it a favorable time further to discuss the question. At present, smaller street lighting must be done with Nernsts, and hence the matter may be considered under two heads, first, that of lamps, and second, that of lanterns.

I have had some experience with D-type Nernsts pointing upwards, but the results were disappointing. The filaments tended to sag down on to the heaters, and this shortened their lives. Also there was an evaporation from the filament on to the Nernst globe, which soon obscured it and reduced the light very much. This evapor-

ation does not get on to the globe when the lamps point downwards, but even then the outer globe reduces the light considerably. The outer globe is needed with D burners, first, because the lamps do not light up well without it, and secondly, to protect the burners when the lantern is being cleaned. It is to be hoped that the Nernst Co. will soon have a good supply of the new AD type burners, which ought to be of considerable assistance; with a lantern which can be cleaned without risk to the burner, no inner globe would be needed for this burner.

Coming to the question of lanterns, manufacturers have not generally grasped the vital points in their design. The first essential is that the lanterns should be cleaned with the same facility as a gas lantern can be cleaned. Many globes are held on by miserable little screws, which are quite unsuitable for their purpose. These are apt to crack the glass if screwed up tightly, or to let it drop if not screwed

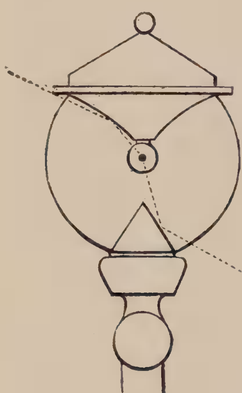


FIG. 1.

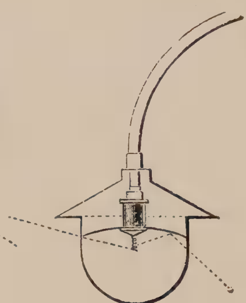


FIG. 2.

up tightly enough. Globes also frequently have such small openings that a man cannot get his hand into them. When they have to be taken off to be cleaned, the man is liable to drop them, especially when he is on a ladder on a cold day.

Fig. 1 shows a lantern which has some merits in that it can be easily cleaned. The lamp hangs downwards, and a reflector underneath assists to direct the light in the right direction. The globe, however, is too big, and its large surface absorbs a lot of light. There is also a tendency to sweating, which is troublesome and difficult to cure. Something can be done by sealing the bottom of the lamp-post with pitch, but occasionally the cure takes a long time.

Fig. 2 shows a kind of lantern which has advantages. The globe is small and fitted to a hinge; it can be cleaned without any screws being taken loose. The globe should preferably be arranged to lower when it is open, to bring it quite clear of the Nernst burner. If this were done, the Nernst could be run without any inner globe, using A type burners. At the present time I know of no one who makes this kind of lantern, but one may hope that something of the kind will be available some day. Most fittings makers have their standard fittings, which utterly fail to come up to common-sense requirements, and they refuse to listen to criticism, simply saying that every engineer has different fads, and although possibly they may occasionally go so far as to admit deficiencies, little is done to improve their patterns.

REFLECTORS.

The ordinary designer of reflectors seems to be obsessed by the idea that light cannot be reflected without sending it back through its source, and most so-called reflectors are made on this plan. Actually, of course, one cannot reflect light back through a Nernst lamp, as the heater, etc., is opaque. Even with the carbon filament lamp the inside and outside of the lamp globe soon become so dirty that reflection of light through the glass means great loss. The first principle of reflection is that as soon as the light gets clear of its source, it should be sent on its appointed path in the shortest way, and without getting a chance to become weakened by having again to traverse any dirty glass surfaces. The style of such a reflector is shown in fig. 2. This kind of arrangement would give the maximum possible illumination in the street, and be immensely more effective than the ordinary oyster shell which is usually used to reflect the light through the lamp again. Fig. 1 shows a kind of reflector which is somewhat common. The sketch shows its shape perhaps more vertical than ordinarily made, but it is sufficient to show that a very large part of the light can go skywards.

Its results can never compare with those of fig. 2, only, unfortunately, the fig. 2 type does not appear to be on the market.

Some good might be done by the Nernst Co., if they would show a little more enthusiasm in meeting requirements. Thus their delay in providing A-type burners to fit the D-type lamps is inexplicable on commercial grounds, seeing that by this means they must have immensely restricted their chances of getting street lighting. Not only do the A-type burners give a better result for street lighting; but they have, according to common report, a better life, and this is something where Nernsts are concerned.

May one hope that some discussion on the question may awaken our friends, the manufacturers, so that they may produce fittings more worthy of the traditions of the electrical industry.

LIGHTING AND EXTINGUISHING GAS-JETS FROM A DISTANCE

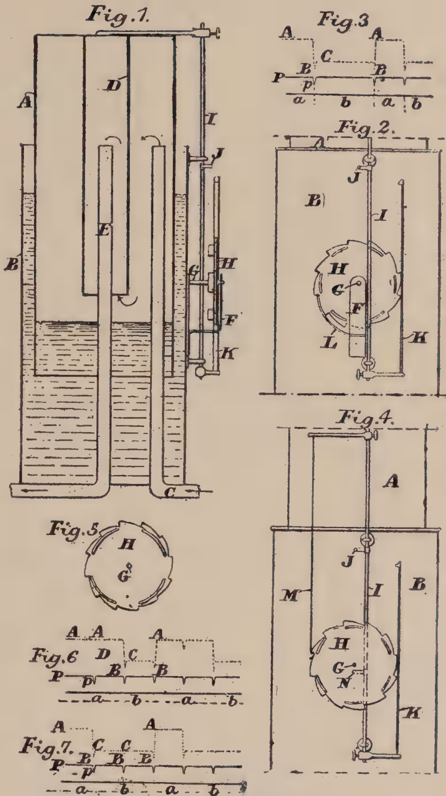
Journal of Gas Lighting (London), July 3, 1906.

As mentioned in the account of the proceedings at the congress of the Society Technique which appeared in the *Journal* last week, a paper upon the above subject was presented by M. Aublant. It was particularly the patent specification of an appliance for lighting and extinguishing gas-jets by varying the pressure of the gas in the mains. It is claimed for the system that it is particularly applicable to public lamps; but it can also be utilized in certain cases in private houses, shops, etc.

The apparatus consists of a movable gasholder, which has at the bottom the gas inlet-pipe, and is also furnished with a movable pipe, one end of which is hydraulically closed or opened as the pressure is lowered or increased, so as to cut off the gas or allow it to enter the pipe from the holder, and thence flow into a fixed pipe connected with the burner, which is furnished with a spongy platinum igniter or some similar device. There are also a series of projections formed upon a rotating disc (a sort of ratchet-wheel), so arranged so as to prevent the bell rising or falling beyond a certain point at the proper time. This disc revolves automatically through a certain angle whenever the bell moves under the influence of variations of pressure; and in this way the projections move forward successively in suitable order and keep the bell down when it tends to rise, hold it up when it is about to fall, or leave it perfectly free. Consequently, by means of a series of relatively momentary reductions of pressure in a main supplying gas to several appliances, different effects can be obtained with certainty, according to the arrangement of their respective sets of projections.

In the accompanying illustrations, two forms of the appliance are shown. Fig. 1 is a vertical section of it in the position for igniting the gas, and fig. 2 a vertical side section; fig. 3, a diagram recording the different pressures of gas and the corresponding motions of the holder; fig. 4, a partial side elevation of a second form of the apparatus in position for lighting; fig. 5, a variant of the disc; and figs. 6 and 7 are diagrams recording the different degrees of pressure of gas and movements of of holder when discs similar to those shown in figs. 4 and 5 are employed.

In figs. 1 and 2, A is the gasholder, moving vertically in a vessel B containing a suitable liquid—for example, heavy petroleum oil—as a seal. The gas is conveyed into the holder by the pipe C, which is connected with the main. At the top of the holder is a pipe D, closed at the top, into which another pipe E, connected with



Aublant's Apparatus for Lighting and Extinguishing Gas-Jets.

the burner. On one side of the vessel B is fixed a bearing F, which supports the shaft G of a disc H, furnished with teeth on the circumference as well as with projections on one of its sides. The latter are fixed opposite the teeth, with spaces between. A rod I, attached to the gasholder, moves freely in guides fixed upon the vessel B. It is furnished with a catch J, which is so arranged as to pass into the spaces or come into contact with the projections according to the position of the disc. Moreover, there is a flexible catch K, on the lower part of the rod I, which presses against the teeth on the disc H, making it revolve one tooth each time the holder falls completely—the position *B*, indicated by broken lines on figs. 3, 6, and 7. Another flexible catch L, fixed to the bearing F, acts on the disc in such a way as to prevent it turning backwards.

The action of the appliance is as follows: It is arranged at the gas-works that the pressure in the main will be as usual, and will be nearly constant all day (say 24-10ths), but that at certain times it will be lowered for a few moments to 12-10ths. The gasholder is placed so that it can be raised as far as possible (position *A* in

figs. 3, 6, and 7) by the higher pressure *P*, and fall to position *B* with the lower pressure, *p*. In the position indicated in fig. 1, the holder is raised. The gas enters it by the pipe C, passes into D (the lower end of which is above the liquid), makes its exit by E, and reaches the burner, where it is automatically ignited. During this period, indicated at *a* in fig. 3, the disc presents a space on the upward path of J, so that the rod I can drop to its full extent. The pressure of the gas is indicated in the drawing by a full line, and that of the holder by a dotted one; and it is reduced at any given moment from *P* to *p*. The holder then immediately falls into position *B*. At the same time the pipe D dips into the liquid, and cuts off the gas from the burner, which is extinguished. Moreover, the catch K makes the disc rotate one tooth; so that a projection is brought to the empty space immediately after which the catch J has passed it. The reduction of pressure thus produced only lasts for a moment, and then the normal pressure *P* is restored, and the holder again ascends. But as the catch J is stopped by the projection above, the holder does not ascend further than position *C*, and the lower end of the pipe D remains in the liquid, so that the burner is not again ignited. The movement from *B* to *C* is, however, sufficient to make the catch K rise over another tooth of the disc. In fig. 3, the extinction period is indicated by *b*. At a moment determined upon, the pressure is reduced from *P* to *p*, and the holder again falls to the position *B*. Consequently, the catch K makes the disc revolve one tooth, and present a space above the catch J. When the ordinary pressure is once more restored, the holder rises to its full extent (position *A*), gas enters by the pipe D, and the burner is ignited automatically. This operation is repeated every time the pressure is reduced and increased; and it goes on simultaneously in all the appliances on a main.

The form of apparatus shown in fig. 4 comprises the parts already described and, in addition, a catch M fixed on the rod I in such a way as to make the disc rotate one tooth each time the holder ascends. The rod has also a second catch N. The action of the appliance is then as follows: The holder being raised fully, and a projection being on the path of the catch N, the gas passes to the burner. When the pressure is reduced, the holder falls as far as the catch N, rests on the projection, and is thus held in position *D* (fig. 6), so that the pipe D is again over the liquid. Consequently, the light continues to burn. When the higher pressure is restored, the holder ascends to position *A*; but in this movement the catch M turns the disc one tooth. On the pressure being again reduced, the catchers J and N no longer encounter any obstacle, and the holder falls again to position *B*, cutting off the gas. After this movement, the catch K again makes the disc rotate one tooth. The higher pressure being then restored, the holder rises; but it is stopped in position *B*, owing to the contact of the catch J and the projection above. The burner remains extinguished until another reduction of pressure causes the holder to fall and turn the disc one tooth. When immediately afterwards the pressure is increased, the catches J and N have free passage, and the holder ascends to its full extent, and the burner is lighted.

If in an apparatus like that shown in figs. 1 and 2 the disc of fig. 2 is replaced by that of fig. 5, in which each projection passes over a space corresponding to two teeth, the operation is different. Every time the pressure falls from *P* to *p*, the catch K turns the disc one tooth; but when the pressure *P* is restored, the holder cannot ascend to position *A* more than once in three times, being twice retained in position *B* to keep the gas shut off. It will thus be seen that if appliances with discs like that shown in fig. 5 and others of the type shown in fig. 4 are all connected with the same main, they will simultaneously ignite the respective burners; but those of the first type will cause extinction before the second, though all are subjected to the same changes of pressure.

Of course, by varying the proportions and grouping of the projections in relation to the spaces and the teeth of the disc, any other combination of movements of the holder can be obtained, with a view to produce, at any predetermined time, ignition and extinction of each of the burners supplied from the same main.

THE MERCURY VAPOR ARC LAMP

Electrotechnische Zeitschrift (Berlin).

This name is applied to the lamp invented by Otto Vogel, of Berlin, which is a combination of the ordinary enclosed arc lamp and the mercury vapor lamp. The lower part of the lamp is shown in Fig. 1. Mercury is placed in the lower part of the enclosing globe to such a depth that the lower carbon projects a slight distance above the surface. A funnel-shaped condenser made of sheet metal is placed in the upper part of the globe; the particles of carbon and mercury vapor gather upon this condenser and thus prevent the blackening of the enclosing globe. The lamp runs on 10 amperes at 50 volts. The arc spreads out gradually from the negative carbon, reaching a length of 20 mm., and increases in size as the mercury evaporates. In Fig. 2 is shown the arc between 2 mm. solid carbons, the lower carbon extending 5 to 6 mm. out of the mercury.

W is the white core of the arc, which is surrounded by a yellowish mantle R. D is a dark zone between the core and the mantle. The arc travels around the carbon once in 10 to 20 minutes. The positive carbon does not form a crater, while the negative is slightly rounded off. The base of the arc on the negative carbon increases with the strength of the current and covers a

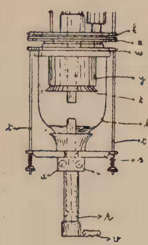


FIG. 1.

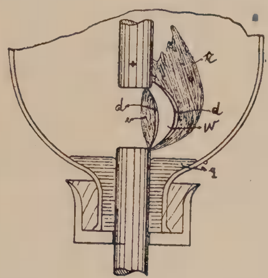


FIG. 2.

circle of 4 to 6 mm. circumference, while on the positive it is only 1 to 2 mm. in circumference. The color of the light depends upon the height of the negative carbon above the surface of the mercury, that is, upon the extent to which mercury vapor participates in the radiation of light. After the vapor begins to form the current falls to 9 amperes and the tension remains at 56 volts. Several of the lamps may be burned in series.

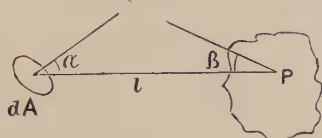
When the volatilization of the mercury is rapid the whole inner globe is like an incandescent ball. A lamp of 2,200 candle-power gives us an efficiency of about 0.27 watt per Hefner candle. The strongest rays are 30° below the horizontal. In a 12-ampere lamp with 14 mm. carbons the burning away of the positive carbon is ¼ mm., that of the negative 1/10 mm. per hour. A 400 mm. positive carbon will therefore run 1,600 hours. The regulation which is at present done only by hand is necessary only after 40 to 50 hours of burning. There is no loss of mercury, since the rising mercury vapors are condensed and run down in drops in the space between the condenser and funnel. With correspondingly larger carbons and current strength arcs 150 mm. long and 70 to 80 mm. wide can be produced. If the light is to be colored, cored carbons containing the required salts may be used, or the salts may be sprinkled upon the surface of the mercury; also in place of pure mercury amalgam containing the metals necessary to produce the desired colors—sodium, copper, potassium, strontium, etc., may be used. By this means, however, not only is the color changed, but also the form of the arc.

THE GLOBE PHOTOMETER

Electrical Review (London).

We have recently received from Dr. L. Bloch a reprint of an article from the *Elektrotechnische Zeitschrift*, (1905, Nos. 46, 47), giving an account of the theory of and experiments with, the Globe photometer; and Dr. Bloch sends us in MS. a revised account of the mathematical theory of the instrument. The principle of the method was described by Prof. Ulbricht (*Elektrotechnische Zeitschrift*, 1900, No. 22), but is not, we believe, generally known, or in common use, so that some account of it will be of interest to electrical engineers. The function of the apparatus is to give by one observation the value of the whole amount of light emitted by any source, such as an arc lamp or an incandescent lamp. It has no relation to the light distribution in different directions, to which other ordinary methods of measurement are applicable. The general theory is as follows: When a source of light is placed inside a spherical shell having a matt surface, the light received by any part of the interior surface can be divided into two parts—(a) the light received directly from the lamp, and (b) the light received from the remainder of the interior surface of the sphere, after one or more reflections. The quantity (a) is

FIG. 1.



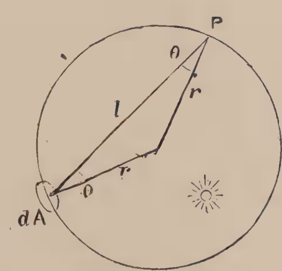


FIG. 2.

that which is measured in the usual photometers which determine the intensity of the light emitted in one direction, and is not considered at all in the Globe photometer. By the theory of the Globe photometer the quantity (b) is constant all over the surface of the shell, and is proportional to the total amount of light emitted by the lamp, quite independently of its position in the shell.

In other words, if a lamp be hung inside a spherical shell with a matt lining the illumination of any part of the shell which is screened from the direct light of the lamp is the same as of any other part, and measures the total amount of light measured by the lamp.

The argument is as follows: Suppose a surface P (Fig. 1) to be illuminated by radiation from a small luminous area d A, whose brightness is B; then, by the ordinary formula, the light received by a unit surface at P is B d A cos a cos B/l^2, a, B being the angles made with l by the normals to the two surfaces.

Next let Fig. 2 represent the spherical shell of the photometer into which is inserted for measurement a lamp, roughly indicated in the figure, and consider the illumination of the surface at the point P by light reflected from a small area d A. The circle drawn is that central section of the shell which passes through d A and P. Let the light received directly from the lamp on to the small area d A be L_A . d A; so that f L_A. d A (integrated over the sphere) = E, the total light emitted by the lamp. Then the brightness of d A, which being perfectly matt throws light equally in all directions, is k L_A, k being a constant for the the particular matt surface used; and (using the expression of the last paragraph) the face at P is k L . d A $\cos^2 \Theta/l^2$ which = light received from d A on a unit of sur- k . L_A d A/4 r^2. This last expression gives the illumination at P by light which has been once reflected from the lamp by the surface d A. Hence the illumination at P by once reflected light from the whole surface of the sphere = $k/4\,r^2$ f L_A . d A = $k/4\,r^2$. E.. It follows at once that the illumination at P by twice reflected light = $(k/4\,r^2)^2$. E. So that the total illumination at E by reflected light = E $(k/4\,r^2 + (k/4\,r^2)^2 + (k/4\,r^2)^3 + \ldots)$ = K E, where K is a quantity depending only on the dimensions of the sphere, and the quality of its internal surface. It is, in fact, a constant of the instrument. The illumination then by reflected light is uniform all over the surface of the shell, and is proportional to E; so that, screening off the direct light from the lamp from any small area, the remaining illumination of that area is a measure of the total light emitted by the lamp.

The strict application of the above argument requires a perfectly matt surface, and that the fittings or mechanism of the lamp shall not interfere with the repeated reflections by the surface of its own light; neither of which conditions can be entirely met in practice. The first condition is met approximately by coating the surface with lithopone (barium sulphate), and the second by making the shell large compared with the lamp; and experiments show that the errors do not prevent useful results being obtained.

The apparatus consists of two parts, the spherical shell or globe, and the measuring instrument or photometer.

The globe (Fig. 3) is constructed of two hemispheres 1 meter in diameter pressed out of sheet zinc, 2 mm. thick. The hemispheres are bolted together by screws to a steel ring, so that the shell can be opened when required, and the whole is mounted upon a tripod stand of a convenient height for observation. Large holes are made in the top and bottom for the insertion of the lamps, and three small holes, 50 mm. diameter, on a vertical meridian to be used as observation holes. The whole of the inside is covered with a white paint (barium sulphate) which has an approximately perfect matt surface. A perfect matt surface is one which reflects light equally in all directions independently of the direction of the incident light, and the coating of barium sulphate satisfies this condition sufficiently for practical purposes. In using the apparatus the lamp is introduced into it through one of the large holes, and the photometer is

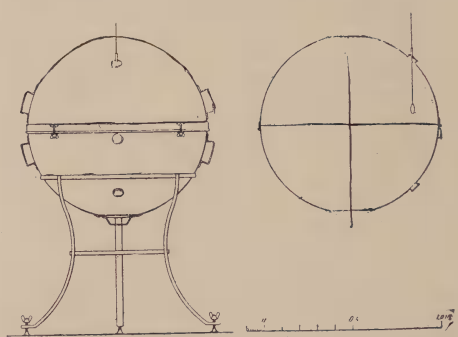


FIG. 3.

brought to one of the observation holes. The small screen used to shield the photometer from the direct light from the lamp is seen in position in the sectional view. In some cases, *e. g.*, ordinary incandescent lamps, the source of light is lowered completely into the globe; but in the case of an arc lamp, in which the mechanism is bulky and would interfere considerably with the reflected light, the arc may be placed at or near the surface of the globe, the greater part of the mechanism being then outside. When the lamp is placed completely inside the globe the mean spherical intensity is obtained by dividing the result of the measurement by 4π; but when it is at the surface only that part of the total light is measured which is emitted below the horizontal plane, and dividing the result by 2π gives what Dr. Bloch terms the mean hemispherical intensity for the lower hemisphere.

The photometer used by Dr. Bloch was designed on the principle of Dr. Brodhun, and was manufactured by the firm of

Messrs. Franz Schmidt & Haensch, of Berlin. It is shown in perspective in Fig. 4, and in Section in Fig. 5. A small plate of plaster of Paris, S (Fig. 5), having a matt surface, is illuminated from the source under measurement by light passing along the tube T. Light emitted from S is reflected through the prism *k*, the lens system below *h*, and the prism W into the eyepiece *l*. On the other side light from an opal glass screen *d*, illuminated by a small incandescent lamp *g*, passes through a lens system, through the prism system *p p* and the prism W up into the eyepiece L. The prism W is made in two parts, which touch one another all over the surface shown in the figure by the oblique line of division. They are cemented together over a small central elliptical area, so as to be in optical contact there, but not elsewhere. Light falling on the surface from the left—*i. e.*, coming from S—is reflected upwards into the eyepiece, except from the cemented area, through which it passes freely and is lost. Light falling on this surface from the right—*i. e.*, coming from *d*—passes freely upwards through the cemented area into the eyepiece, and is reflected back from the rest of the surface. Consequently, the field viewed through the eyepiece consists of a central circular area illuminated from *d*, and a ring enclosing it illuminated from S. The manipulation of the instrument consists in adjusting the handle *t*, and so regulating the light from *d*, until the central circular area seen under the eyepiece appears to be equally luminous with the surrounding ring. It remains to explain the construction of the prism *p p* and the regulator *t*. The two prisms *p p* are mounted upon an axle driven by a small electric motor M, and supposing no screens or diaphragms are interposed, the light from *d* will fall continuously upon W after four reflections through the two prisms, notwithstanding the rapid rotation of the system. The pair of diaphragms *t*, shown in plan at N, are designed to interrupt the light during each revolution to an extent that can be adjusted and indicated from outside by a scale attached to the handle *t*. The form of the diaphragms, of which one is fixed and one movable, is shown at N, and each has a pair of sector-shaped apertures which may be made more or less completely to correspond with one another. By Talbot's law, the illuminating effect of a rapidly intermittent light is proportional to the time it is seen, and is independent of the mode of intermission, provided that the intermissions are sufficiently rapid not to be perceptible. By moving *t*, the light passing from *d* to W, and the consequent brightness of the central area seen in the eyepiece, can be regulated in a proportion read exactly by the scale of *t*, and independent of the speed of the motor. Thus this photometer compares two sources of light, not as is usual with other photometers, by adjusting their relative distances from the observing apparatus, but by rapidly interrupting one of them in a determined way

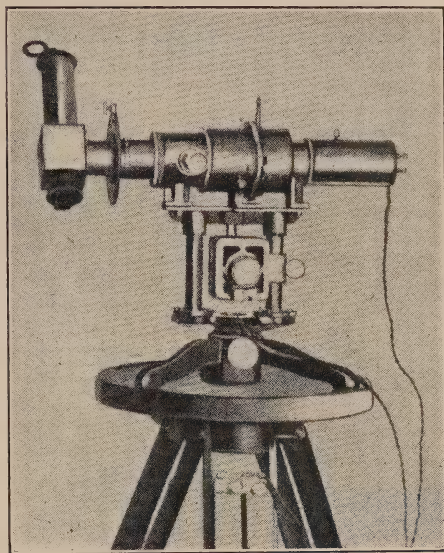


FIG. 4.

until they appear equally bright in the observation eyepiece.

It will be noticed that the tube T (Fig. 5) is constructed to turn about the general

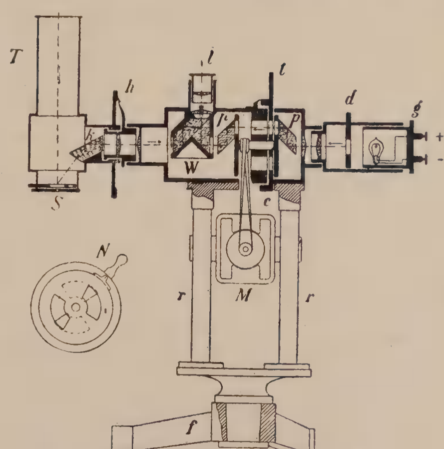


FIG. 5.

axis of the instrument, and that its position can be noted by the attached scale and pointer *h*. This enables the observer to compare any given light with a standard light, *e. g.*, a Hefner lamp, by directing the tube first to one and then to the other, and

adjusting the interrupter t in each case to obtain a uniformly lighted field under the eyepiece. Then the two readings of t give the ratio between the two lights.

The last point to consider is the determination of the constant of the globe itself, which is done by placing in it, and observing, a standard or a previously standardized lamp, when the reading of the Brodhun photometer at one of the observation holes is compared with the reading of a Hefner lamp placed at a measured distance.

In conclusion, we extract from Dr. Bloch's paper the figures of a set of tests made on an incandescent lamp to determine how closely the observed values corresponded with the theory of the instrument. The lamp was hung near the center of the globe, and observations were made from the three observation holes p', p, p''. Fig. 6 shows the general arrangement with the photometer in position at each hole. Measurements were taken with and without a shade over the lamp, and with and without screens between the photometer and the light. Fig 7 shows the distribution of the light from the lamp with and without the shade, the

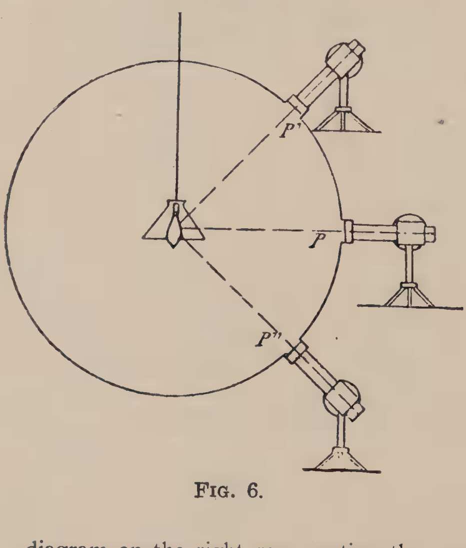


FIG. 6.

diagram on the right representing the case with a shade, that on the left without. The figures obtained were as follows:

Conditions of the experiment.	P'.	P.	P''.
Lamp unshaded, observation hole not screened	56	54	58
Lamp unshaded, observation hole screened	41	40	41
Lamp shaded, observation hole not screened	28	27.5	48
Lamp shaded, observation hole screened	28	27	27.5

It is seen that in both cases when the direct light of the lamp is screened off, and only the illumination by light reflected from the walls observed, the result is closely the same for all the three windows. The result with the shaded lamp, whose light distribution is very irregular, is the more instructive.

Dr. Bloch's paper gives some details of

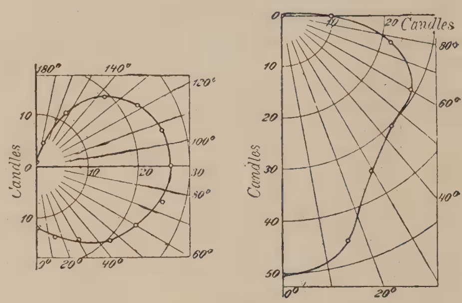


FIG. 7.

construction beyond what we have obstracted, as well as the results of a large number of observations made with the same lamp placed first near the middle of the globe and afterwards at the surface, giving in one case the mean spherical intensity, and in the other the mean hemispherical intensity. For these, and for a much longer mathematical treatment than appears to be necessary, we refer our readers to the original papers in the *Elektrotechnische Zeitschrift*.

A DISCUSSION OF INVERTED INCANDESCENT GAS-BURNERS

Journal of Gas Lighting (London).

In a letter to the *Journal* Mr. Geo. Helps makes the following criticisms of Mr. Victor Rettich's paper on "The Inverted Incandescent Gas Burner," read before the Illuminating Engineering Society:

"The writer of the paper suggests that a mantle of thicker cotton, but with interstices of much greater area, should produce one of the same tensile strength as the present, and decrease the back-pressure in the burner while admitting more oxygen to its interior. It would be interesting to know if the writer is aware of the action of the bunsen flame on the mantle. It may with little uncertainty be taken for granted that he is not. A mantle made on the lines he suggests would not emit any light at all. Again, how any back-pressure is caused in an inverted mantle when the top or mantle-holding ring is open, requires a little explanation.

"All the criticisms of the seventeen burners, to my mind, show that the writer of the paper has had very little to do with burners.

"Certain so-called disadvantages of the inverted burner are set out under twelve different numbers:

(1) Dangers of falling particles.

(2) Carbonization of the mantle.

(3) Flashing-back.

(4) Delicacy of mantle suspension. Whether or no the inverted mantle is strong, depends on the size of it. If an inverted mantle be used the same length as a vertical mantle, I agree that it would not last long; but, on the other hand, the small inverted mantle will last very considerably longer than any vertical mantle.

(5) Flickering light at low pressure. All these defects cannot surely be traced to the burners—that is, if they are of a fairly good kind—but to the supply of gas or the miserable pressure.

(6) Discoloration of chandelier arms.

(7) In many cases a difficulty of attaching lamps so that they will be gas-tight, when set in the required direction. These defects can be entirely obviated if an up-to-date burner and fitting be used.

(8) Methods of regulating the gas are too coarse; a much more delicate way being required. With up-to-date burners, the regulation of the gas may be effected to the finest degree possible.

(9) Liability to break mantles when removing glass. This remark is just as applicable to vertical as to inverted burners.

(10) Variations in the diameter of globe-rings, etc. This is not a question of the burner, but of the glass, and is also applicable to vertical burners.

(11) Variations in means of affixing mantles to burners. This is not a defect of the inverted burner; and doubtless it will very speedily be removed when the best types of burners are accepted and the method of fixing mantles standardized.

(12) Too much heat thrown off in proportion to the quantity of gas used. This remark is quite erroneous. If the burner is anything like respectable, the light thrown in the direction required can be obtained by creating far less heat than by any vertical burner.

"I have ventured to call attention to these several points because readers of the *Journal* generally expect to learn something from their brethren "across the pond"; and the paper in question is, so far as I understand, most erroneous and misleading."

To which Mr. Rettich replies as follows:

Sir:—In your issue of April 24 I read Mr. Helps' criticism on my article on inverted lamps and feel it incumbent upon me to reply to some of the points raised. Before actually answering his letter, I will make a couple of references.

First, at the fifth annual meeting of the Wisconsin Gas Association held at Milwaukee, Wis., on February 14 and 15, the question was asked: "Is the so-called inverted light of to-day any more efficient than the ordinary gas light?" Mr. Thomas J. Lytle, of the American Welbach Company, in the course of his answer, said: "One objection which has been made to these lamps has been the dropping of the particles of incandescent carbon from the mantle, which has been perhaps somewhat dangerous, and in some instances the underwriters have made restrictions against the inverted burner for that reason." In the Welsbach type of inverted lamp, they have overcome this difficulty by the use of a glass protector, which catches falling particles; but in the majority of cases, the bottom opening of the globe does not provide for this contingency.

Second, at a meeting of the New England Section of the Illuminating Engineering Society, in Boston on April 24, Mr. Holmes made the following remarks:

"There is one thing I want to speak of. This is not a place for us to fight about another man's goods; but somebody spoke of the inverted mantle burner. We have in our office, and we have in a certain restaurant in town, some of these inverted mantle burners, and the electric light solicitor considers them an excellent advertisement for the electric light, for the reason that every one of these pretty little brass fixtures is all smoked up from the ascending fumes of the gas. I have seen our electric light solicitors take customers right around to our office and show them the inverted mantle fixtures with the little shade holders all smoked, and the little brass gooseneck all blacked, as in the restaurant I mentioned. I am not a gas man; but the fact remains that the electric fellows consider the inverted burner a good advertisement for electric light."

Mr. Helps says that the references to the seventeen different burners show a somewhat efficient knowledge of the fundamental principles of atmospheric pressure. Is this meant to imply that the inventors of the different types are lacking in knowledge? If this be so, I agree with Mr. Helps that this is true in many instances. I have had several mantles made which have been doubled where the asbestos thread connects them to the clay holder, and have had great success with them; so much so, that should my company elect to put out a burner which carries a mantle of the inverted type, all the mantles will be made in accordance with this specification.

Mr. Helps cannot be acquainted with the condition of New York, otherwise he could not say: "Reduce the quality of the gas or increase the pressure." Perhaps when we have the new works established at As-

toria, which I presume Mr. Helps has read about in the *Journal of Gas Lighting*, we shall then, having an increased volume of gas, be better able to regulate our pressure. Mr. Helps declares that no burner will give a good result with 23-candle-power gas supplied at 12-10th to 15-10th. This being exactly my contention, I fail to see why he writes at such length on the point upon which we agree. He further says that a mantle the same length as a vertical mantle—from which I presume he means one vertically upright, in contradistinction to one vertically downward—would not last long; but he says the "small" inverted mantle will last considerably longer. The word "small" is purely a question of degree. It may be small in length or small in diameter, or both. I quite agree that the bijou mantle should last longer than one of the larger types, 1½ to 2 inches long, connected to a ring of 1¼ inches in diameter.

With reference to faults Nos. 6 and 7, my paper was written with the object of calling attention to such defects as those, so that provision could be made to correct them in the future. As to variation in the diameter of globe rings, I fear Mr. Helps cannot have examined many of these burners. On gauging some at random, I find that the measurements (in inches) are as follows: 3½, 3, 3¼, 3⅛, 3¼, 3½, 3½, and 3⅜.

The variation in means of affixing mantles to burners is certainly not the fault of the inverted burner; but by calling attention to the inconveniences caused thereby, a remedy can be found.

In the matter of the amount of heat thrown off by inverted and upright burners, what I maintain is that, burning a given quantity of gas by the use of an inverted burner, will raise the temperature in a room at breathing level to a higher degree than is true of an upright burner. This is due to conduction and radiation.

Touching the subject of the potential energy of gas, it will simplify matters by making the following formula:

Let X = potential energy (pressure and volume) of the gas.

Let Y = specific gravity of the gas (air = 1, gas = 1—?).

Let A = motionless air.

The upright vertical burner gives a force of $X + Y$ to impart kinetic energy to A. The downward vertical, burning in a hypothetical condition of always remaining cold, gives a force of $X - Y$ to do the same work. Inasmuch, however, as A does not remain cold, but becomes heated, and commences to rise, we then get the force of $X - Y$ having to give kinetic energy to air no longer motionless, but now heated and rising.

I wish it to be distinctly understood that all the remarks that were made in my paper applied to the vertical downward burner. As to the type in which the burner is inclined at a downward angle, as is done in Germany by Ahrendts and Co., and by Mr. Helps himself in England, and in some of my own experiments, I have quite a different opinion. I consider that this method will prove successful over the vertical inverted burner. Further, there is but a very small percentage of electric bulbs that are designed to burn vertically downwards—the greater proportion being always at a downward angle; and if we are to produce effects with gas that have been hitherto associated only with electric fixtures, to repeat myself, the lamp burning at a downward angle is the solution thereto.

With regard to back-pressure in the burner, Mr. Helps has doubtless seen many of the petroleum lamps utilizing mantles. In these cases, the weave of the mantle is very much looser, and the interstices are very much greater, than for a "C" burner, so that the conversion from a luminous to a non-luminous flame may be effected. Many of these lamps without a mantle will give a perfect blue flame; but just as soon as the draft is interfered with by the interposition of a mantle, slight as this special mantle is, it will be sufficient to cause enough back-pressure to prevent the conversion of the luminous flame.

I am free to confess that I am not aware of the action of the bunsen flame on the mantle, though I am trying to keep myself posted by reading the reports of researches made by such physicists as Professor Vivian B. Lewes, Professor Bunte, Professor Nichols, Messrs. White, Muller, and Travers, and other gentlemen who are endeavoring to determine the cause of the remarkable phenomenon of the high luminescence of the mantle. At the present moment, as far as I know, there has been no definite solution of the phenomenon; but one would infer from Mr. Help's remarks that he is acquainted with the cause. I would esteem it a great favor if he would communicate such knowledge to me.

In conclusion, I would like to refer to an extract from my letter to the New York *Electrical World* of March 31 last, as follows: "The purpose of my paper was to show to all interested parties the existing defects, and, in some cases, to suggest slight improvements. If such a paper will hasten the perfection of the inverted lamp, I shall feel that my effort was not in vain."

Victor A. Rettich.

Knickerbocker Light and Heat Company,
New York City.

THE MECHANICAL EQUIVALENT OF LIGHT

By Edward L. Nichols.
[Prof. Physics, Cornell University.]

The Electrical Magazine (London).

Producers of artificial light have been content for a long time to measure their product in units the relation of which to the units of energy expended in its manufacture was unknown. That there is such a thing as the mechanical equivalent of light has, however, been recognized almost from the time when it had been established that radiation is a form of energy and light a special type of radiation. That the determination of the mechanical equivalent of light is not of purely academic or even of purely scientific interest has likewise been recognized, and attempts have been made from time to time to determine it.

The first of these attempts was that of Thomsen,* who in 1865 measured the total energy radiated by a standard candle by comparing the effect upon a thermopile placed at a known distance from the flame with that upon the same instrument when exposed to the radiation from a hollow ball containing hot water. The energy lost in a unit of time by the ball was ascertained from its rate of cooling. To determine what proportion of the radiation from the candle flame was light-giving, Thomsen compared the radiation received by the thermopile, when exposed directly to the flame with that transmitted by a glass cell containing a layer of water 20cm. in thickness.

Twenty-three years later, in 1888-89, Tumlirz† took up the problem. In the meantime the first important step necessary to the success of such an investigation had been made in the substitution for the candle of a definite and reproducible standard of light; and Tumlirz adopted as the subject of his experiments this standard: the flame of the Hefner lamp. As the result of his measurements, which were carried out with extraordinary care and precision, account being taken of all thinkable sources of error, Tumlirz found the light-giving energy received upon one square centimetre of surface at one meter distance from the Hefner flame to be 36.1×10^{-8} gram calories per second. This value is considerably smaller than that obtained by Thomsen, whose result, recomputed and reduced to the same terms, was 56×10^{-8} gram calories per second from the candle flame.

Tumlirz in his paper considered the question of determining the ratio of the light-giving to the total radiation by dispersion of the rays; but he unfortunately rejected this more rigorous method on account of the experimental difficulties which it presents, and contented himself, like Thomsen, with the use of a thick water-cell. He convinced himself of the opacity of this cell to non-luminous radiation by experiments with the Bunsen flame, no portion of the radiation of which was transmitted to the thermopile. This check upon the method is inadequate for the reason that the infra-red spectrum of the Bunsen flame* consist merely of two emission bands, at wave lengths $4.25u$ and $2.70u$; in which regions both glass and water are quite opaque. The infra-red spectrum of a luminous flame such as that from the Hefner lamp, on the other hand, contains a considerable amount of energy of shorter wave lengths which is capable of transmission through both glass and water. The curve B in Fig. 1 indicates the distribution of energy in the infra-red spectrum of the Bunsen flame. The curve W in the same

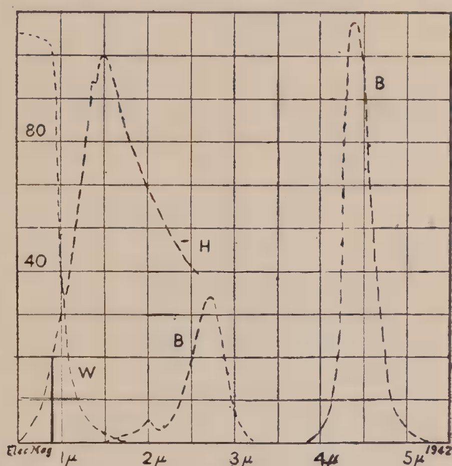


Fig. 1.

diagram indicates the percentage of radiation as a function of the wave length transmitted by a water cell. A portion of energy curve for the Hefner flame H is also given.

The error introduced by the assumption of the complete opacity of the water cell for infra-red radiation is very large. The ratio to be measured may be shown graphically by plotting the curve of the distribution of energy in the spectrum of the source of light and dividing the area enclosed by that curve into two parts by means of a vertical line at wave length $.76u$, which represents the limit of visibility at the red end of the spectrum (see Fig. 2). The ratio of the total area OBCD to the area OBR, which comprises the whole of the light-producing radiation and excludes the infra-red, is the

* Thomsen: Poggendorff's Annalen, 125, p. 348.
† Tumlirz: Wien. Berichte, 9711, pp. 1521 and 1625; also Wied. Ann. 38, p. 640.

* Nichols: Standards of Light; Proc. of the International Electrical Congress at St. Louis, 1904.

quantity to be measured. The energy transmitted by the water cell was assumed to coincide with this area; but such a cell, as we know from subsequent explorations,* actually transmits radiation, the spectrum of which is represented by the curve OB′C′D′. In addition to the light-giving area OB′R, somewhat reduced by losses due to reflection and absorption, the cell transmits infra-red radiation corresponding to the area RB′C′D′, and this exceeds in amount the light-giving radiation. The true value of the ratio of the luminous to the total light-giving radiation from the Hefner flame, as determined by a method free from this source of error, to be considered presently, is about .009. The measurements of Tumlirz, however, gave for this value .024. The first corresponds to the ratio $\frac{OBCD}{OBR}$, the second to $\frac{O'B'C'D'}{OBCD}$.

Further evidence that the measurements of Tumlirz give too large a value for the mechanical equivalent of light may be obtained by computing from his data the energy of total light flux from a source of unit intensity. This quantity, found by multiplying the energy received on a square centimetre at metres distance by $4\pi \times 10^4$, is .04054 gram calories per second or .188 watts for a source one hefner in intensity. A glow lamp at three watts per hefner would therefore have a radiant efficiency of $\frac{.188}{3} = .055$. This value agrees well with the accepted determinations by the older methods for the radiant efficiency, in which the water cell was used as a means of separating the light-giving from the non-luminous radiation.

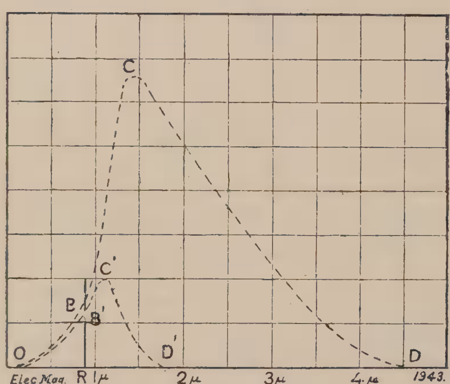


Fig. 2.

The most recent determination, made by C. E. Mendenhall† by a method free from this error gives, however, .026 for an incandescent lamp filament at normal brightness.

In 1903, Knut Angström* made a redetermination of the mechanical equivalent of light and as his investigation affords us for the first time values of this important quantity which are free from large errors I shall describe the method employed in some detail.

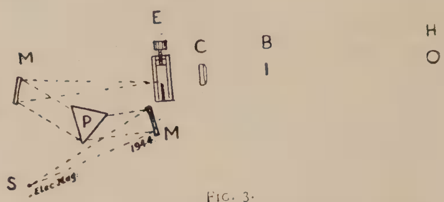


Fig. 3.

Angström's method for the determination of the mechanical equivalent, like that of Tumlirz, consists of two operations: the determination of the radiant efficiency of the Hefner flame and the measurement of the total radiation. His method of finding the radiant efficiency consists essentially of the dispersion of the rays from an incandescent lamp of special construction by means of the mirror spectroscope M P M (Fig. 3), the removal of the infra-red portions of this spectrum by means of an adjustable wedge E—the edge of which could be brought into coincidence with the boundary of the visible spectrum in the red at wave length .76—the reassembling of the visible portions of this spectrum by means of the cylindrical lens C and the measurement of the intensity of light thus brought to focus by means of a bolometer B. The effect upon the bolometer was compared with that produced by a Hefner lamp so placed as to produce an illumination precisely equivalent to that from the incandescent lamp. To secure this adjustment a photometer consisting of an equilateral prism of chalk, enclosed in a circular black box with circular openings, was mounted in place of the bolometer. This prism was so placed that one face would be illuminated by the reassembled light from the visible spectrum of the incandescent lamp, the other by the light of the Hefner lamp. This form of photometer is very sensitive to small differences of color, and it was therefore possible to adjust the current through the lamp so that the character of the light emitted by it would correspond exactly with that of the Hefner flame. The distance of the Hefner lamp from the photometer could then be adjusted until the illumination on the two faces of the photometer prism was equal. The photometer was now removed and the bolometer mounted in its place. The energy reaching it from the incandescent

* See Nichols and Coblentz, *Physical Review*, Vol. XVII., p. 267.

† Mendenhall, C. E.: *Physical Review*, Vol. 20. page 160.

* Angström: Royal Society of Sciences, Upsala, 3rd Series, Vol. XX., 1904.

lamp was that of a visible spectrum precisely equal to the visible spectrum of the Hefner lamp, while the energy reaching it from the latter included likewise the non-luminous energy of the infra-red spectrum. The careful comparison of these two bundles of rays, which are physiologically identical, gave the value of the radiant efficiency—namely, the ratio of the light-giving to the total radiation from the flame. This ratio, corrected for the various sources of error, such as losses by absorption and reflection, was found to be .0096, a value much smaller than that obtained by Tumlirz or by any of the other numerous observers of radiant efficiencies of similar sources who have made use of the water cell. That results obtained by the latter method are necessarily much too large has already been shown.

For the determination of the total radiation from the Hefner flame Angström employed his pyrheliometer, a form of differential bolometer well adapted for such purposes. In this instrument similar strips of metal, forming two arms of a Wheatstone's bridge, are mounted side by side. The change of resistance of one of these, which is exposed to the radiation to be measured, is counterbalanced by sending a sufficient current through the other strip to heat it to precisely the same temperature. In this way the energy received by the exposed arm can be determined in absolute measure. Angström found the radiation received upon one square centimeter of surface at a distance of one meter from the flame in the horizontal plane to be .0000215 gram calories per second. The luminous radiation from the flame is therefore

$$L = .0096 \times .0000215 = 20.6 \times 10^{-8} \frac{\text{gram calories}}{\text{seconds, cm.}^2}$$

This quantity, as is expected from the smaller value for the radiant efficiency, is much less than that obtained by Tumlirz. The latter observer, as has already been stated, recognized the more exact character of the dispersion method subsequently employed by Angström, but rejected it on account of the great difficulty of the adjustments. It becomes of interest to inquire therefore whether Angström's value is really more accurate than that of his predecessor or whether he has, on account of the experimental difficulties of the method, fallen into errors as great as those involved in the method of the water cell.

We may note in the first place that the smaller result obtained by Angström is in the direction of greater accuracy; and we are happily able to test its accuracy in a fairly rigorous manner by comparing the radiant efficiencies thus determined with those obtained by still another method, which, while it involves equally serious experimental difficulty, is exact when properly carried out. This method consists in the exploration of the entire spectrum with a sufficiently delicate instrument, such as the bolometer or radiometer, the plotting of the curve for the distribution of intensities, and the comparison of that portion of the area of this curve which represents luminous energy with its total area. The visible spectrum of the Hefner lamp is so feeble that accurate measurements of this portion of the curve are almost impossible. In the case of a more powerful source of light, such as the acetylene flame, it is, however, possible to explore the visible as well as the invisible spectrum, and to obtain a curve from which the necessary integrations can be made.

The radiant efficiency of the acetylene flame determined by the method of the water cell * ranges between .08 and .105. The values obtained by integration of the energy curve lie between .033 and .045. Angström by the same method which he applied to the Hefner standard, found .056. The discrepancy between these values is much less than that between Angström's value and those obtained with the water cell. It may, indeed, perhaps be entirely accounted for by differences in the character of the flames employed.†

Angström also made use of his apparatus for the determination of the distribution of energy in the visible spectrum of the Hefner flame by moving the wedge S (Fig. 3) to different positions and measuring for each position the luminous energy included between the edge of the wedge and the violet end of the spectrum. From Wien's Law it is possible from a series of such measurements to compute the distribution of intensities throughout the region explored and in this manner to obtain the energy curve even where the various wave lengths are too feeble to be measured separately. The great value of such a curve lies in the fact that from it the corresponding curves of all sources of light which have been compared by means of the spectrophotometer with the Hefner standard may be readily computed. The curve for the acetylene flame thus obtained is found to be identical with that obtained by direct measurements with the bolometer, and this coincidence affords the strongest evidence of the substantial accuracy of Angström's values for the mechanical equivalent of light.

By making use of Angström's curve of intensities for the Hefner lamp and the corresponding curve for the acetylene flame similar curves may be plotted for all other sources of light which have been compared spectrophotometrically with either of these; and if such curves be drawn in such a way as to represent in each case a light source of unit photometric intensity a comparison of their areas, taken for the whole of the

* Nichols: *Physical Review,* Vol. XI., p. 215.
† Nichols and Coblentz: l.c.

visible spectrum, gives the mechanical equivalent of light for each source in terms of that of the hefner. I have shown in a recent paper * that the mechanical equivalent thus computed is not constant, but varies through considerable range with the character of the light. The smallest values are those for sources strong in the wave lengths of high luminosity in the middle of the spectrum and *vice versa*. Tables I., II., and III. give the results of such computation for three distinct groups of light sources. The mechanical equivalent is expressed in watts of the total light flux when the mean spherical intensity of the source is one hefner.

Where light is produced electrically, the efficiency, commonly expressed in watts per candle, may be given some absolute significance by the substitution of the ratio of the

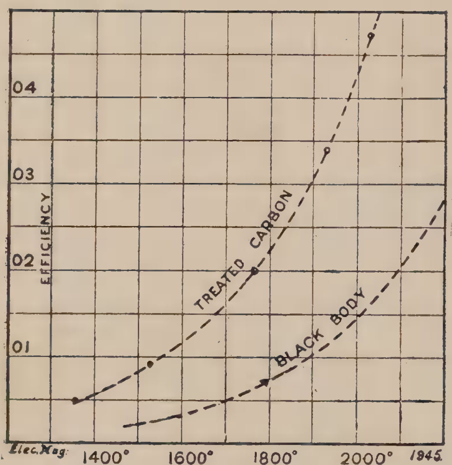


Fig. 4.

watts of total light flux to the watts necessary to maintain the source. This ratio, which is not identical with the radiant efficiency, because it includes the heat losses in the lamp by convection and conduction, is given in Table IV., for a treated lamp filament studied by Blaker.† The watts of light flux are as given in Table II.

These efficiencies are greatly in excess of the theoretical radiant efficiencies of a black body for the corresponding temperatures. In Fig. 4 the efficiency of treated carbon, as given in Table IV., and the theoretical efficiency computed from Wien's Law by Mendenhall‡ are plotted as a function of the temperature. There is an almost constant difference between the two curves, which indicates the superiority of treated carbon as radiator of the visible wave lengths, long since noticed by Evans,* Bottomley,† and the present writer.‡ The incandescence of the treated filament—for any temperature between 1,400° and 1,900° Abs.—is equivalent, photometrically, to that of a black body of more than three hundred degrees higher temperature. The temperature of a treated filament at a normal brightness of three watts per hefner (3.4 watts per candle) is approximately 1,900° Abs., and its radiant efficiency is .032. A black body to attain this efficiency must be brought to about 2,250°.

For flame sources, where the amount of fuel consumed and its heat of combustion are known, the gross efficiency—*i. e.*, the ratio between the rate at which energy is developed by combustion and the watts corresponding to the total light flux of the source—may be computed. Wedding § in a recent paper has published such data for numerous sources of light, basing them on measurements of his own of the total radiation, luminous radiation, and the total energy required to maintain the light. His determinations of the luminous radiation, like those of Tumlirz, were made by the method of the water cell. The other factors, however, which appear to be carefully worked out, may be used in combination with the values of the luminous radiation, already given, for the computation of the efficiency of these sources. Preece,|| also, in an address before Section A of the British Association, has furnished estimates of the power of the fuel consumed by various flames in watts per candle. Data from both of these writers, whose results are unfortunately by no means concordant, are used in Table V.

The exceedingly small amounts of energy necessary to illumination, were we in a position to effect the complete transformation, may be illustrated as follows:

A source, the illuminating power of which at meter's distance is equivalent to one watt per centimeter of surface would be of more than a million candle-power, or, to be more exact, it would have an intensity:

1,160,000 hefners for the Hefner flame, and about the same for candles, oil, and gas.

1,400,000 hefners for acetylene.

1,580,000 hefners for a glow lamp with treated filament at three watts per hefner.

1,690,000 hefners for the arc.

Tumlirz in the article cited in the opening paragraphs of this paper offers numer-

* Nichols: On the Distribution of Energy in the Visible Spectrum; Paper read before the American Physical Society, Dec. 29, 1904.
† Blaker: *Physical Review*, Vol. XIII., p. 357.
‡ Mendenhall: l.c.

* Evans: Proceedings of the Royal Society, Feb. 18, 1886.
† Bottomley: Proceedings of the Royal Society, 42, 1887.
‡ Nichols: *Physical Review*, Vol. II., p. 260.
§ Wedding: Über den Wirkungsgrad und lie praktische Bedeutung der gebraüchlichsten Lichtquellen; München, 1905.
|| Preece: B. A. Report, 1888; also *Nature*, Vol. XXXVIII., p. 496.

TABLE I.—LUMINOUS FLAMES.

Source.	Mechanical equivalent of light as below. Ergs of luminous energy per cm.² of surface when illumination is one lux.	Total light flux in *watts*, for a photometric intensity of one hefner.
Hefner Standard	8.68 ergs per sec.	0.1090 watts
Petroleum. Flat wick	9.13 " "	0.1148 "
Petroleum. Triumph burner	8.69 " "	0.1092 "
Illum. Gas. Batswing	8.45 " "	0.1062 "
Illum. Gas. Sugg burner	7.70 " "	0.0968 "
Acetylene	7.12 " "	0.0892 "

TABLE II.—CARBON—ELECTRICALLY HEATED.

Source.	Temp.	Mechanical equivalent of light as below. Ergs per cm.² per lux.	Watts of total light flux per hefner.
Carbon rod (untreated)	1000° C.	29.0 ergs per sec.	0.364 watts
	1100°	23.15 " "	0.291 "
	1200°	17.80 " "	0.223 "
	1300°	14.20 " "	0.179 "
	1400°	9.14 " "	0.114 "
Lamp filament (Angström)	1727°	7.26 " "	0.0912 "
Lamp filament (treated)—Blaker.	1078°	18.5 " "	0.217 "
	1255°	9.69 " "	0.122 "
	1328°	7.38 " "	0.0928 "
	1496°	7.34 " "	0.0793 "
	1648°	6.35 " "	0.0798 "
	1738°	6.42 " "	0.0807 "
Arc	———	5.80 " "	0.730 "

TABLE III.—METALLIC OXIDES.

Source.	Mechanical equivalent of light as below. Ergs per cm.² per lux.	Watts of total light flux per hefner.
Zircon	7.17 ergs per sec.	.090 watts
Lime. Old	5.89 " "	.074 "
Lime. New	7.21 " "	.096 "
Welsbach Mantle	4.44 " "	.056 "
Magnesia (from burning ribbon)	5.53 " "	.0695 "

TABLE IV.

Temperature. C.	Abs.	Watts per hefner.	Watts of flux.	Watts of flux. Watts per H.
1078°	1351°	46.0	.217	.00506
1255°	1528°	13.8	.122	.00882
1496°	1769°	4.54	.0923	.0203
1648°	1921°	2.34	.0789	.0344
1738°	2011°	1.71	.0807	.0472

TABLE V.—GROSS EFFICIENCY OF FLAMES.

Source.	Watts of light flux. Watts per hefner.	Watts of fuel burned.
Tallow Candle	109*	.00092
Sperm Candle	75*	.0013
Petroleum	70*	.0016
Petroleum	38†	.0029
Coal Gas	59*	.0015 / .0016
Welsbach	53†	.0010
Acetylene	13.5‡	.0060
	8.0‡	.0110

References for Table V.

* Preece.
† Wedding.
‡ See Nichols: *Physical Review*, Vol. II., p. 215.

ous computations of this sort, and other interesting data are to be found in a paper by Carl Hering.*

Langley has computed the minimum energy necessary to vision. For the wave lengths of highest luminosity in the middle of the spectrum his value is 2.78×10^{-9} ergs. The human eye at meter's distance from a source of light of one hefner intensity, viz., when exposed to an illumination of one lux, receives energy at a rate (about .6 erg per second) many millions of times as great as that necessary to maintain vision, and it is not altogether overwhelmed even when the intensity of the illumination rises to 1,000 luxes.

*Hering: *Electrical World*, April 20, 1901, p. 31.

Miscellaneous News

ALBANY, N. Y.—The Gold Car Heating and Lighting Company, of New York City, was incorporated to-day, at the Secretary of State's office, with a capital of $3,000,000. The directors are Edward E. Gold, Richard V. Voges, John C. Dixon, Henry J. Horn, Lucius E. Varney, Ambrose L. O'Shea, New York; Edward J. Ronan, Brooklyn.

AUBURN, N. Y.—Mayor Aiken of Auburn has won his fight for dollar gas in that city. After August 1 the price will be $1.10 a thousand, with a discount of ten cents if the bills are paid promptly. This is the result of an agreement between the Auburn Gas Company and the city authorities. Complaint had been made to the State Commission of Gas and Electricity but this has been withdrawn.

BOSTON, MASS.—The Boston Heat, Light and Power Company, which owns the electric and gas lighting plants in Clinton and Leominster as well as in twenty-five or thirty other towns and cities in the State, is to build an immense power plant for the generation of electricity at Still River Depot, in the town of Harvard. Surveys of the property to be acquired are now being made.

BUFFALO, N. Y.—The State Commission of Gas and Electricity received to-day the complaint against the Buffalo Gas Company, made by James N. Adam, Mayor of Buffalo. Accompanying the application for cheaper gas, both to the city and private consumers, is a request that the complaint shall take precedence over a similar complaint against the Buffalo Natural Gas Fuel Company. The hearing in the latter case had been fixed for July 26. It is now probable that the Buffalo Gas Company's case will be taken up as soon as complaints from Syracuse and Albany are disposed of. In case the commission should decide to give a hearing it probably will be held the latter part of August or in September.

CHICAGO, ILL.—The Edison and Commonwealth companies have notified the city that they have no present intention of reducing their rates for electric light lower than the recent cut they made. The information came in a letter from William G. Beale, counsel for the companies, to Chairman Young of the council committee on gas, in which the request of the committee to be allowed to put its examiners on the companies' books to get data for an ordinance fixing the rates was refused.

The companies did offer, however, to allow a committee composed of James B. Forgan, Victor F. Lawson, and Bion J. Arnold to examine their books as to capitalization and operating expenses, and in order to save the city money to pay the cost of the experts they might employ.

FORT SCOTT, KAN.—A movement has been inaugurated in the City Council looking toward the establishment of a municipal lighting plant. It is not intended, however, that the plant shall furnish current for private consumers only.

GENESEO, N. Y.—Alexander Wyness, Jr., has just resigned from the superintendency of the Geneseo Gas and Electric Light Company of this village with the intention of taking up a similar position with a large gas, electric light and electric railway syndicate, with its headquarters in Michigan. Mr. Wyness many years ago planned and built the municipal plant in Batavia.

HUMBOLDT, KAN.—This city is to have an elaborate lighting plant, which will afford street lights and lights for commercial use. The city council has granted a franchise to V. G. Sprinkle and others to build and operate an electric lighting system in Humboldt. The stock for the enterprise has been subscribed and the plant will be built at once.

JERSEY CITY. N, J.—A New Jersey charter for a $100,000 concern which proposes to operate on the Island of Zanzibar, off the east coast of Africa, was obtained yesterday by the organizers of the Zanzibar Electric Light Company. The articles of incorporation, filed with County Clerk John Rotherham in Jersey City, set forth that the company will generate, furnish and distribute electric current for heat, light and power. The incorporators are B. S. Mantz, Thomas F. Barrett and Felix Ingold, all of 15 Exchange Place, Jersey City, the registered office.

LOS ANGELES, CAL.—It has been settled that the city is to pay half of the cost of lighting Broadway for the ensuing year. An assessment district is to be drawn up for the other half, which will be paid by Broadway property owners. The city contract for lighting Broadway expired June 30. The total cost of lighting Broadway for the first year was $14,315.10. The entire cost was borne by the city. The city is to pay the entire cost of lighting Main and Hill Sts. for the first year. Under the lighting law, the lights will thereafter be paid for by levying an assessment upon the property owners, the city probably paying a proportion. The new contracts are to be so worded that the city may reduce the candle power and number of lights to save expense, or increase them at will.

MUNCIE, IND.—The city of Muncie, Ind., having definitely decided to abandon its municipal street lighting plant because of the expense of operation, and to enter into a contract with a private company to furnish light for the streets, is now re-

ceiving bids from electric light companies. Only two bids have been handed in thus far—one by the Muncie Electric Light Company, which agrees to light the entire city at the rate of $57.50 a year for each light for the first 260 lights and $45 a light in excess of 260; the other by the Indiana Traction Company for $65 a year for each light, not less than 260 lights to be used. Too much politics has been assigned for the cause of abolishing the municipal plant.

NEWARK, N. J.—Articles incorporating the People's Light and Power Company were filed in the County Clerk's office yesterday. The incorporators are Philip N. Jackson, Oliver W. Jackson and Joseph I. Conlon, and the capital stock is put at $500,000, of which $10,000 is paid in. Philip N. Jackson said yesterday that the new corporation is a holding company and was formed to take control of four electric light companies in New Jersey and develop them. One of these companies is presumably the Shore Electric Company at Red Bank, which Mr. Jackson organized about a dozen years ago. He says the People's Company is not to enter the field of the Public Service Corporation.

NEW YORK CITY.—Because of the reductions in price of lighting the city streets and public buildings, the city is likely to abandon its project of establishing a municipal lighting plant. Although the city has already acquired a site for the establishment of such a plant, and has on file a report of experts as to the cost of maintenance, it is likely, in view of the changed conditions, that the work will be halted, temporarily at least. The city has not yet officially abandoned the project, but if the application for the appropriation is denied, it is not likely that any more money will be spent on the plant already projected.

A certificate of incorporation was granted in Connecticut to Parker, Sheehan & Hatch for the organization of the Northern Westchester Security Company, with a capital of $2,400,000.

The application was signed by F. A. Stratton, Charles H. Werner and Louis B. Grant, and stated that the object of the company was to acquire and own stocks, bonds and other securities of public service corporations. It is said that the new company is really a merger of the Gas and Electric Lighting companies and trolley lines in Northern Westchester and Eastern Connecticut. F. A. Stratton was president of the Westchester Lighting Company.

OAKLAND, CAL.—Considerable progress has been made towards more adequately lighting the main streets in central Oakland. Electroliers to be erected along Broadway and Washington streets, from Seventh to Fourteenth, are now being cast at Oakland Iron Works, and are promised for delivery within a month from now. An even more ambitious lighting project is progressing—that of placing electroliers along Twelfth street from Jefferson street easterly to Lake Merritt; also on Twelfth street dam and along the boulevard as far as completed on east shore of Lake Merritt.

A committee of Chamber of Commerce members, including Will J. Laymance, chairman, Henry Abrahamson of Abrahamson Brothers, J. C. Downey of W. P. Fuller & Co., A. J. Snyder and Chas. H. King, capitalists, has the project in hand. This committee reported Thursday in favor of having the same style of electroliers that are to be placed on Broadway and Washington streets, and the board of directors adopted the report.

City Engineer Turner for the committee made an estimate that it would cost 92 cents per front foot of private property along Twelfth street and the boulevard, to put up the electroliers.

The lack of illumination of the principal business streets has been sorely felt the last three months. Twelfth street is now a very busy thoroughfare and constantly becoming more so. With Broadway, Washington and Twelfth street lighted as proposed the central city will take on new life at night, and it is confidently predicted that property owners on San Pablo avenue, Telegraph avenue, Broadway north of Fourteenth, and those of all the cross streets in the central business districts, will soon follow suit and erect electroliers.

ORANGE, N. J.—City Engineer Frederick T. Crane has completed work on the maps of the city showing the location of electric lights to be run in connection with the city electric light and power works.

The new plant is designed to supply current to private consumers and power to run the pumping machinery at the sewer and water works and light the streets, all at a figure considerably under the amount charged for years by the Public Service Corporation. There now seems no doubt that the plant will be in full operation in a few months.

PENN YAN, N. Y.—An illuminated carnival will be held under the auspices of Keuka Yacht Club on Tuesday, July 17. All owners of sail or power yachts and as many row boats as possible, whether members of Keuka Yacht Club or not, are requested to decorate their boats with lanterns and participate in the parade.

PHILADELPHIA, PA.—The Citizens' Electric Light Company has been chartered at Harrisburg, with a capital of $10,000. With the support of the Committee of Seventy, it will compete with the Commonwealth Electric Company for the city lighting contract.

The directors and incorporators are Er-

nest C. Bruckman, Pelham Manor, N. Y.; Walter A. Worrall, New York, and Lewis Davidson and Matthew K. Sniffen, of this city.

PORTLAND, ME.—The deal for merging Portland's two electric lighting systems has been completed. Standard Oil capital is said to be backing it. The Portland Electric Light Company was incorporated, with $1,500,000 capital. The company has purchased the water privileges and the Hargraves Woolen Mills at West Buxton, on Saco River, and will establish an extensive electric plant there, to furnish power to the woolen mills and supply electricity to Portland for manufacturing purposes.

ROCHESTER, N. Y.—On Wednesday, August 1st, Second Vice-President W. M. Eaton, of the Rochester Railway and Light Company, who is also general manager of that corporation, will turn over the duties of the latter office to a successor, who has already been appointed. It is a promotion for Mr. Eaton, and comes as a direct result of the work he has done in Rochester.

Mr. Eaton resigned the office of second vice-president and general manager of the Grand Rapids (Mich.) Gas Light Company on June 3, 1904, to accept the office of general manager of the Rochester Railway and Light Company, the duties of which he assumed twelve days later, within a few weeks after the merger that resulted in the organization of the Rochester Railway and Light Company became effective.

The new general manager is R. M. Searle, at present general manager of the Westchester Lighting Company, with head offices in Mount Vernon, N. Y.

Mr. Searle is about 38 years old and has held his present position for about four years. He went to Mount Vernon from the Atlanta (Ga.) Gas Light Company, of which he was general manager for about six years. The company was organized in 1856, and Mr. Searle introduced modern methods into the company. For several years previous to his going to Atlanta, Mr. Searle was general manager of the company that supplies Johnstown and Gloversville, this State, with gas and electricity.

SCHENECTADY, N. Y.—The heads of the municipal departments are agitating the matter of the construction of a municipal lighting plant. They allege that the present rates for lighting are excessive and propose to convert an old pumping station into a generaing plant.

SCRANTON, PA.—The first step toward municipal ownership of an electric light plant to light the city was taken July 13, when Common Councilman Albert Davis, of the Fifth Ward, introduced a resolution directing the Director of Public Works to have prepared plans and ascertain the cost of a plant fully equipped with machinery for the furnishing of electric lights for the entire city.

SENECA FALLS.—The Seneca Edison Company of this place has made application to the State Commission of Gas and Electricity for permission to consolidate with the Geneva Power and Light Company.

TOPEKA, KAN.—The Topeka Electrical Company was granted a franchise for thirty years by the city council last night and within eighteen months Topeka will have a new electric lighting plant, which will cost in the neighborhood of $125,000 or the franchise will become invalid. In return for the franchise, the electrical company will have to operate and supply power for thirty street lights on Kansas avenue from the north to the south limits of the city. The franchise provides for maximum rates to be charged as follows:

For residence lighting, nine cents per thousand watt hours.

For commercial lighting, six cents per thousand watt hours.

For power, five cents per thousand watt hours, except power for electric elevators, for which the maximum rate shall be six cents per thousand watt hours.

For all electric current furnished to the city of Topeka for lighting the city prison, fire stations, and all other municipal buildings (except the Auditorium, to which the rates for commercial lighting shall apply), and for power, the rate shall not exceed four cents per thousand watt hours; and for lighting public school buildings the rate shall not exceed four cents per thousand watt hours.

TRENTON, N. J.—Governor Stokes has signed the bill of Assemblyman Jones, of Camden, enabling that city to construct and maintain a municipal light, heat and power plant.

WATERTOWN, June 17.—Since the incorporation of the Watertown Light and Power Company and the announcement that it was a consolidation of the Watertown Gas Light Company and the Watertown Electric Company it has been rumored that one effect would be felt in an increase of prices and that John B. Taylor would not be connected with the new corporation.

Mr. Taylor says in an open letter: "If I am connected in any way with the new organization, and I expect to be, I hope that as soon as the process of construction has been passed through by these companies, probably about December 1, a schedule of prices both for gas and electricity will be arranged that will give the consumers a substantial reduction from the present prices."

The Illuminating Engineer

Vol. I. AUGUST, 1906 No. 6

Practical Problems in Illuminating Engineering

VI. LIGHTING A MERCHANT TAILOR'S SHOP

By Arthur A. Ernst.

The present case is not an elaborate one, nor one requiring any high degree of engineering skill, but simply a fair example of the ordinary problem which the electrical contractor or central station solicitor is continually being called upon to solve.

The room is occupied by Hansen & Shackleton, located at 5 W. 42nd St., New York, and is 19 feet wide by 64 feet long, with ceiling 8 feet high. Daylight is admitted only through the show windows in the front. The interior finish consists of an oak wainscoating about three feet high around the walls, above which the walls are tinted a buff color. The ceiling is of pressed steel painted light gray. The woodwork is finished with a blue-gray tint of "weathered oak." The general plan of the room with arrangement of tables, mirrors, etc., is shown in Fig. 1.

The original installation consisted of five chandeliers fitted with four electric and four gas lights each, spaced uniformly down the center of the ceiling. The electric lamps were turned down at an angle of 45° and equipped with small porcelain shades. The chandeliers had been at one time equipped with incandescent gas burners; but these were not satisfactory to the proprietor, and the electric lamps were used instead. The faults of the lighting by this method were unequal illumination on the various counters and tables, insufficient intensity on the goods, and obstruction of the view by the chandeliers, which were of wrought iron design and finish.

In this case it was required to produce a higher illumination at the counter level without increasing the amount of current. The means used were required also to have a generally sightly or decorative appearance, and the light furthermore must be fairly accurate in color values, or at least not give distortions in appearance from either daylight or artificial light conditions. Arc lamps would have given the required intensity of illumination, but were rejected on account of the difficulty of making them decorative, especially as the ceilings are low, and also on account of the cold effect produced by their bluish light. As another condition was to keep the cost of changes in the installation as low as possible, it was decided to resort to

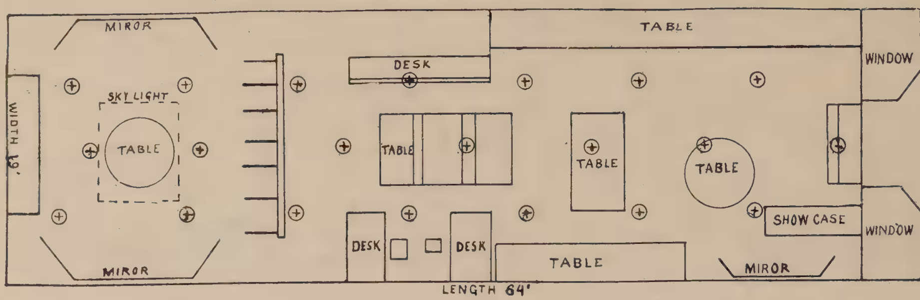


FIG. 1.—FLOOR PLAN, AND POSITION OF LAMP ON CEILING.

the very simple expedient of placing ordinary 16 candle power 3.1 watt lamps in a symmetrical arrangement. This necessitated some additional wiring; to provide for this, and at the same time add to the appearance of the room, a 4 inch oak molding, finished like the rest of the woodwork, was placed so as to form three rows of panels lengthwise of the ceiling. At the intersection of the molding, and in the center of each panel in the center row, a lamp and reflector were placed, a flat canopy and socket being the only fixture used. This required the use of twenty-three lamps and reflectors. In the original installation there was a six light cluster under a flat porcelain reflector placed over the entrance, making twenty-four lamps in all. The change in installation therefore reduced the number of lamps by one.

The curve of distribution of the reflector used, and the horizontal intensity on a plane five feet below the lamps (counter light) is shown in Fig. 2. It will be seen that this shows a maximum of somewhat over one foot-candle produced by a single lamp, and the additional light from different sources, with the diffuse reflection from ceiling and walls, will probably raise the general intensity on this plane to nearly two foot-candles. For the illumination of dark and non-reflecting goods, like woolens, this may be thought rather low, and it certainly would not be wise in any case to provide for less, and would probably be better generally to calculate on a little more. In the present case, however, the proprietor is well satisfied with the results. The removal of the chandeliers and placing the lights close against the ceiling adds both to the apparent height and size of the room, while the scattering of the units gives the appearance of greater general illumination.

As was stated at the beginning, the changes made were simple, but the results, so far as the user is concerned,

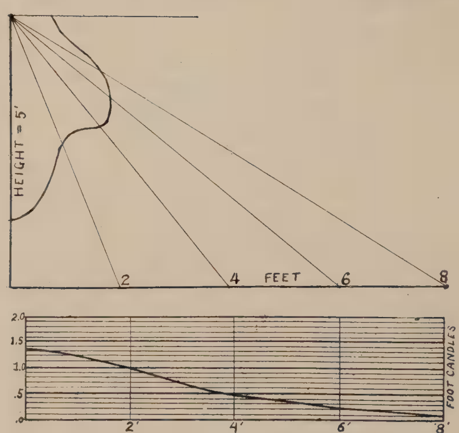


FIG. 2.—CURVES OF DISTRIBUTION AND ILLUMINATION.

are entirely satisfactory, and a discontented user of electric light has been turned into a satisfied customer.

There are any number of similar cases in which like simple expedients would produce the same general result; and it is among such simple, every-day cases that the illuminating engineer must, at least at the beginning, find a large proportion of his work.

The Illumination of the Federal Building, Chicago, Ill.

By J. E. Woodwell.

In the preceding article upon this subject the decorative fixtures and general scheme of illumination of the public spaces of the building were described and illustrated. In each of the minor offices and work rooms as well as the large offices and floor areas assigned to more than 4,500 employees in the Postal service, practical problems in illumination were encountered in the greatest variety. In the smaller offices and work rooms throughout the building the principal illumination is secured from fixtures of relatively simple design and of a type whose efficiency has been demonstrated by experience.

Fixtures of the type shown in Fig.

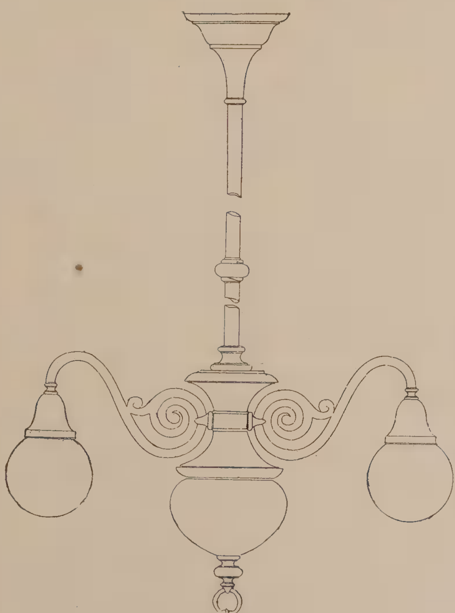


FIG. 1.

1 and Fig. 2, are used in the more important office rooms and are equipped with finial switches controlling each individual light separately. In the minor offices 3 to 5 light pendants of the design shown in Fig. 3 are used, hung 7′ 0″ from the floor in rooms of a ceiling height of 10 feet or less and

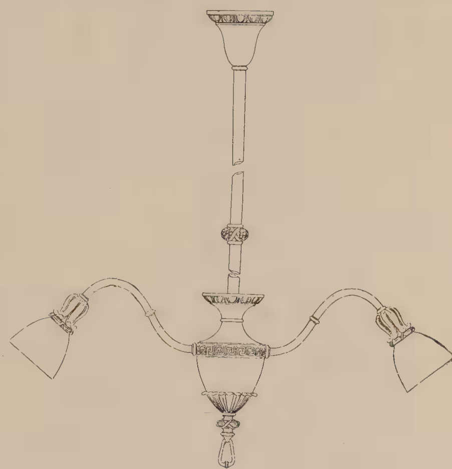


FIG. 2.

8 feet in cases where the ceiling height exceeds 10 feet. For small stair halls and corridors a simple 2 light ceiling fixture of the type shown in Fig. 4 is used, the length being 15 inches for ceilings 10 feet high or less, and 24 inches for higher ceilings.

The large working areas of the Post Office are equipped with 6 and 8 light pendants of the type shown in Fig. 5, hung generally at a height of 10 feet, and in small rooms 8 feet from the floor. The last three types of pendants described above are furnished with pendant switches hung within reach for the control of the lights.

The angles at which the sockets are placed on the above fixture were studied with reference to securing in connection with the use of Holophane reflector shades the most effective distribution of the light. To relieve the socket from the weight of the glass shade and to provide a rigid support

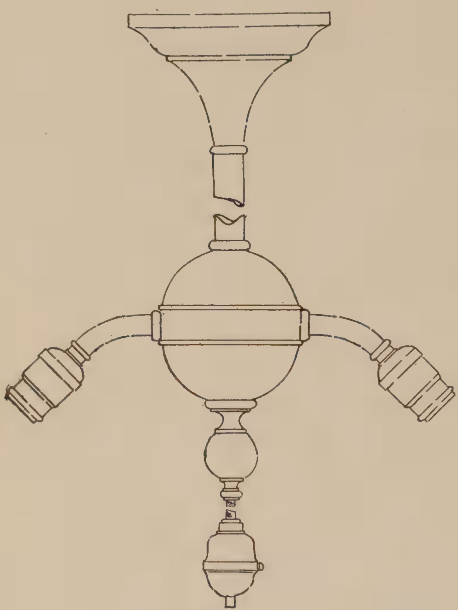


FIG. 3.

Figure 6 shows a simple and inexpensive form of electric bracket used in vaults, storage rooms, etc. Brackets of the type shown in Fig. 7 are used in bath and toilet rooms, one design having a swivel joint and swinging arm by which the lamp may be swung in various positions when located adjacent to a wash-bowl and mirror. With white walls an excellent illumination is secured in small bath rooms by the use of one light bracket of the above type, equipped with a special Holophane bracket

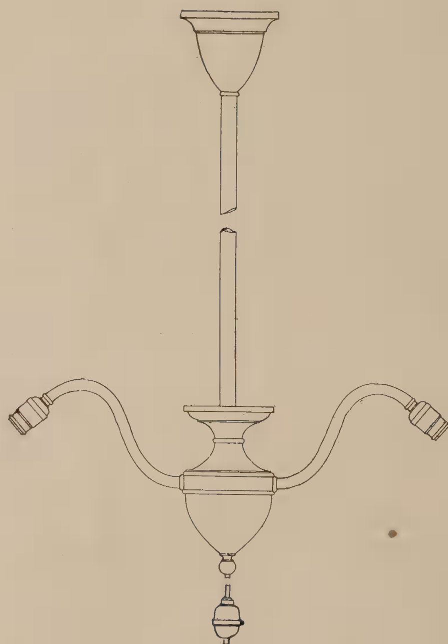


FIG. 5.

for the glassware at the proper angle it will be noted that all of the fixtures are equipped with a metal husk or spun shade holder completely inclosing the socket and substantially secured to the arm of the fixture.

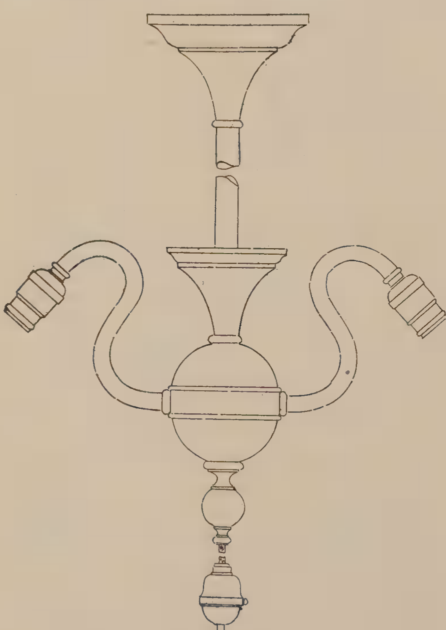


FIG. 4.

shade and an 8-candle-power lamp. Chain pull sockets are used on all bracket fixtures for the control of lights.

In certain vaults, closets, bath rooms, etc., a single pendant of the form shown in Fig. 8 is used, while in small and narrow passages a two-light pendant of the simple design shown in Fig. 9 is installed. The fixtures above illustrated aggregating over 8,000 lights, constitute the larger proportion of the regular fixture

equipment and are typical of numerous special designs not mentioned. Some idea of the important part these relatively simple fixtures, averaging in cost less than $2.50 per light including prismatic shades, play in the general scheme of work rooms and office illumination may be gained when it is realized that the area illuminated by fixtures of the types shown exceeds 10 acres.

In the Post Office working rooms many special features of illumination are provided in connection with the

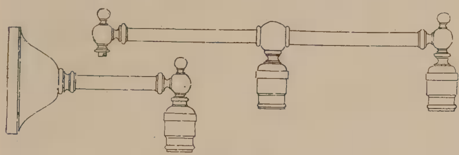


FIG. 6.

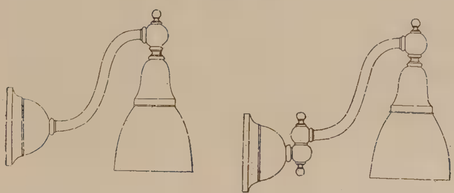


FIG. 7.

sorting sacks, pouching tables, distributing cases and other furniture with which this portion of the building is fully equipped. Some of the conditions to a successful solution of the problem of illumination in the postal work rooms are that the method chosen shall prove equally satisfactory, with respect to the intensity and position of the light, to three shifts of employees working consecutively throughout the twenty-four hours. The fixture installed and the method of its wiring and connection must be such as to permit of the relocation of the furniture with the least cost and labor, while the control of the lamps must be such as to enable the enforcement of stringent rules to prevent waste of light when not required. Finally the method chosen should be economical, especially in view of 16 or 18 hours' service daily.

In attempting to solve these prob-

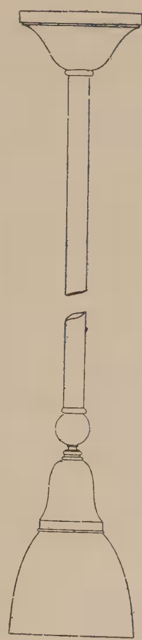


FIG. 8.

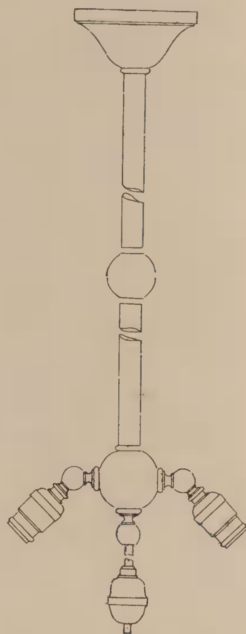


FIG. 9.

lems to the best advantage nearly every form of commercial lighting accessory has been tried and experimented with under actual working conditions.

As a result of these tests the lighting system finally adopted for the postal service on the entire second floor of the building, about 85,000 square feet in area, includes for a basis of general illumination 312 one-light pendants and 34 three-light clusters, all equipped with 8-candle-power lamps and prismatic reflectors. The pendants are spaced 12 to 14 feet on centers and are arranged to be controlled in groups of 6 to 12, according to the divisions of office work and arrangement of furniture.

An important branch of the work performed on the floor is the sorting of mail on tables, and its distribution in pouch racks. To meet the exacting requirements of this work for illumination, special fixtures of the design shown in this photograph, Fig. 10, have proved most successful. The conduit support is attached permanently to the pouch rack and may be moved

FIG. 10.—SORTING AND DISTRIBUTING MAIL.

with it if desired. Socket connections are conveniently made in the conduit by the use of "condulet" fittings, while the circuit for each pouch rack is controlled and protected by a switch and inclosed fuses mounted on a single base at a convenient location. The illumination secured by the use of 8-candle-power lamps with prismatic reflectors spaced about 2 feet apart in the position shown on the photograph, has proved amply sufficient in intensity while the distribution of light obviates the shadows and retinal fatigue which have accompanied the use of more powerful concentrated light sources. 384 lamps are arranged in the manner above described.

The mail sorting for the city divisions is performed in the pigeon-holes of furniture cases and for this work each carrier case, 643 in all, is equipped with an adjustable bracket fitted with a key socket, 8-candle-power lamp, and parabolic-shaped metal shade with a satin finish interior reflecting surface. The bracket is adjustable as to height, angle of socket, and swivel to the right and left in order to suit the individual preference of the employees, while each row of cases subject to change in floor location is connected to an adjacent section or to the working system of the building, by means of a fitting of the same type as is used for electrical connections between a trailer and motor car in street railway practice. The two halves of this trailer connection are identical and permit the interchange of groups of cases or the removal of complete sections to another part of the work room and their subsequent connection for electric lighting service without the usual interruption in the latter and labor and cost of making temporary and permanent electrical connections.

In the money order division on the first floor, clusters fitted with prismatic

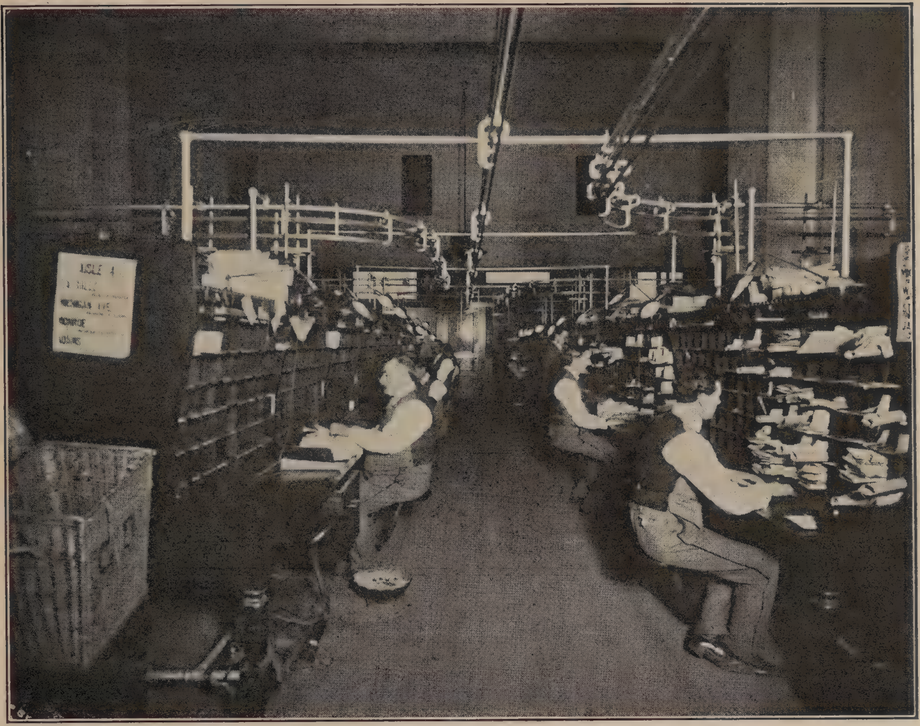


FIG. 11.—SORTING TABLES LIGHTED WITH LAMPS IN REFLECTOR SHADES.

FIG. 12.—MONEY ORDER DEPARTMENT. TABLES LIGHTED WITH CLUSTERS UNDER PRISMATIC REFLECTORS.

FIG. 13.—MONEY ORDER DEPARTMENT. TABLES LIGHTED WITH PORTABLE ADJUSTABLE LAMPS IN REFLECTOR SHADES.

reflector shades are used over the advice tables as shown in the photograph, Fig. 12, while in another section illumination for similar table work is secured entirely by adjustable brackets as shown in Fig. 13, the fixture being similar in type and containing the same features of adjustability as the bracket used on the sorting cases mentioned above. Both of the latter schemes of lighting provide adequate illumination but are accompanied by a certain amount of objectionable reflection of the light from papers on the tables to the eye.

For the illumination of the interior driveway and mailing platform, multiple enclosed arc lamps of 6 ampere capacity and fitted with opal outer globes are at present employed, but in view of the superiority demonstrated by the Cooper Hewitt lamp in similar locations the installation of the latter to displace the arc lamp is now under contract. The Cooper Hewitt lamp will also be installed in certain other locations in the Post Office work rooms where the hours of service are practically continuous.

In conclusion, the features worthy of especial note in this illustration as a whole are the use of lamps of 8-candle-power with prismatic shades, the design of fixtures as to the height and position of lamp and reflector to secure proper distribution of light and finally the control of lights by pendant or finial fixture switch, chain pull socket as well as by wall and group switches to render possible an administration which would prevent waste in the use of light.

Plain Talks on Illuminating Engineering

By E. L. Elliott.

Every civilized human being uses artificial light every day. When the light of a fire, or from the flame of a candle or oil lamp was the only means of producing light, there was little to know about its use, and correspondingly small chance that it would be used to advantage. At the present time the production and use of light is such a complicated subject, and the different purposes for which it is used so various, that the chances are in favor of the average user securing results far inferior to the best obtainable. Poor illumination is so common that the majority of people still consider it one of the necessary evils, and continue to suffer the inconvenience, with only an occasional kick against the bills of cost to show their recognition of the faults.

There are undoubtedly a large number of people who would willingly spend the time necessary to learn how to secure better and more economical results if the necessary knowledge, set down in plain, untechnical language, and expressed as briefly as possible, were readily obtainable. For the purpose of reaching this class of our readers, we shall attempt to set forth in a series of talks the most important facts and principles pertaining to the subject of Illuminating Engineering. In such a treatment of the subject, there will necessarily be statements of many elementary facts with which the professional is already familiar; but such as find the matter trite or uninteresting have the easy remedy of "skipping" it. It is easier for the professional to skip what he already knows than for the layman to find a simple explanation of what he does not know.

Illuminating Engineering is a somewhat high sounding expression, and lest the reader be overawed at the beginning by this combination of large words, it will be well to analyze their meaning, and get a clear idea at the outset of the nature and scope of the subject which we propose to discuss.

Illumination may be defined roughly as the use of light. The word "engineering" is a familiar term—so familiar as to suggest only a vague idea to the lay mind. We hear of "civil engineering," "mechanical engineering," "electrical engineering." "sanitary engineering," and "engineering a deal." In all of these cases it is evidently meant that certain special knowledge relating to the particular subject mentioned is applied in such a systematic manner, and in accordance with such established rules and laws peculiar to the conditions, as to bring about results that could not otherwise be obtained. The engineer is, above all, a *practical* man — one who *applies* knowledge to the achievement of substantial and practical results. The illuminating engineer is therefore one who by reason of his special knowledge of the subject of light, can so arrange the various materials, apparatus and agencies required in its production and use as to secure better results, *i. e.*, better illumination, than can be obtained by one not possessing such accurate knowledge and skill.

Engineering partakes both of the nature of a Science and an Art. Science signifies the special and accurate knowledge; art, the skill and judgment which is required to successfully use that knowledge. Knowledge alone, no matter how complete or exhaustive it may be, can never make a successful engineer; it might make a successful professor. The general formula for the engineer to keep in mind is this:

Knowledge + judgment = Engineering.

Knowledge can be secured by study: judgment comes partly by

nature, but mostly from experience. All we can hope to accomplish, then, in our present discussion is to make plain such elementary and fundamental principles of the subject as to furnish a sound basis upon which judgment may rest.

The knowledge requisite as a basis of any branch of engineering must first of all be exact. Mathematics in general may be considered as exactness reduced to its last analysis; hence the important part which this subject forms in all engineering courses.

Exactness begins in a definition of terms. Definitions are dry reading, but they are to science what the alphabet is to literature—an absolute necessity for its study and understanding. It is particularly essential that we give careful attention to the matter of definition in our study of the principles of illumination, for the reason that this matter has unfortunately been sadly neglected thus far, with the result that a great deal of confusion, misunderstanding, and error has become common.

We have stated that illumination may be defined as light put to practical use. Let us therefore first set about studying the nature of light. The text books say that "light is that form of energy which is capable of affecting the optic nerve," which means that light is that which enables us to see things. It produces, to be sure, many other effects besides that which we call vision; but with these we have very little to do, so far as the present subject is concerned.

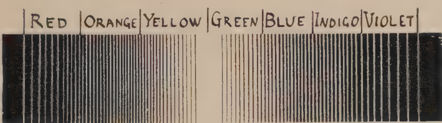
The word light is also used in two other senses than the one which we have just designated: thus, it is sometimes used to mean the *effect* of light upon the eye, as when we speak of "seeing light"; and it is also very commonly used to designate the *source* of light, as when we speak of a "gas-light," or "electric light." For the sake of accuracy it will be best to use the full term, light-source, to signify that which produces light, leaving the word "light" to have always its one single meaning; viz., the physical cause of the sensation of vision.

The nature and action of light forms one of the most obtruse subjects in all natural science; but the knowledge of its properties and action so far as is required for the general practice of illuminating engineering is not beyond the comprehension of the average mind.

It is known with almost absolute certainty that light is a wave motion in a substance, or "medium" which fills all space, and which is designated by the term "ether." It is thus in a way similar to sound, which is a wave motion transmitted through the air. The waves which constitute light, however, are enormously more rapid in their motion than sound waves, and have a corresponding greater velocity; while sound ordinarily travels about 1,600 feet per second, light travels 142,000 miles in a second, and the slowest of the vibrations which affect the eye are at the rate of 3,920,000,000,000,000 per second. This number is far beyond the comprehension of the human mind; and it is one of the striking facts of science that a number of such magnitude has been determined with a doubtless almost perfect accuracy. The action of these rapid vibrations or waves upon the eye produce the effect which we know as vision; the rate of vibration, however, which is capable of effecting the eye and producing the sensation of light, or vision, varies through a considerable range. The rate above given is, as stated, the lowest which can so affect the eye, and any rate from this up to 7,600,000,000,000,000 per second produces the visional effect.

The different rates of vibration, while producing the general effect of light, give rise to the differences in quality which we know as color. The slowest rate of vibration produces dark red, and the most rapid, pale violet. Between these extremes are ranged the other colors, in the order in which they appear in the rainbow, and as set down in the diagram below.

If the rate of vibration is less than that which we recognize as red light, it ceases to produce the effect of vision, and constitutes what is known as radiant heat. Such rays are called *infra red rays,* meaning rays below the red. The radiations that are more rapid than the violet, and which likewise do not produce the sensation of light, are called *ultra violet rays,* meaning rays beyond the violet. From the fact that such rays act upon certain chemicals, they are also frequently called "actinic rays."



VISUAL EFFECT OF THE DIFFERENT COLORS.

The rays which most powerfully affect the eye are those which we designate by the color as yellow. The rays on either side in the order given in the diagram produce less visual effect. This is represented roughly by the shading of the band in the diagram. The different colored rays of light spread out in their natural order is called a Spectrum. The rainbow is thus the spectrum of the sun's light, or solar spectrum. Light from other sources may have a different spectrum, as we shall see later.

It will perhaps help to an understanding of the nature of light to compare it again with sound: thus, the spectrum, or range of colors, is in light the exact counterpart of the musical scale in sound; red corresponds to the note of lowest pitch capable of being heard, while violet corresponds to the highest pitch, and the intermediate shades of color to the different notes in the scale.

Light, both natural and artificial, is always accompanied by heat, in fact, the red rays are undoubtedly capable of producing both sensations. Heat is the only agency through which we can produce light artificially; and the one great problem in the production of light is therefore to secure the greatest amount of light to a given proportion of heat. The immediate source of light is always a hot body or substance. In general, the higher the temperature of the body the greater amount of light will be produced in proportion to the heat generated, and the higher efficiency of modern light-sources is due to the discovery of means of raising bodies to, and maintaining them at, a higher temperature than was formerly possible. An ordinary flame consists of invisibly small particles of carbon heated to incandescence. The phrase "heated to incandescence" is the technical expression meaning, heated to the point of giving out light: an incandescent body is one which gives out light.

Besides giving out more light in proportion to the heat, the light also increases in whiteness, that is, comes nearer to the color of sunlight, at the higher temperatures. Thus the central draft kerosene lamp burners give a much whiter flame than the ordinary flat wick burner, for the reason that the extra supply of air furnished to the flame causes it to burn at a higher temperature. The filament of an incandescent lamp offers another familiar illustration of the same fact; when run at over voltage, it gives a much whiter light, and produces more of it for a given amount of current. In order to secure high efficiency, therefore, the incandescent body must be able to withstand a high temperature, *i. e.,* be highly refractory. Carbon is one of the most refractory of substances; one form of it, graphite, is used in making crucibles, that are to be used in high temperature work. This property enables it to be used in both incandescent and electric arc lamps. The arc lamp is much more efficient than the incandescent for the single reason that the portion of the carbon which produces the light is heated to a very much higher temperature by the arc than it is possible to maintain the carbon filament of the incandescent

lamp; and this also accounts for the whiteness of the light. As the temperature of a body is increased, the amount of blue and violet rays is increased, so that at higher temperatures the light runs into these colors, as in the case of the arc. The color of the light emitted is thus an indication of the temperature, a fact which is made use of in metallurgy and other operations requiring great heat, to judge degrees of temperature.

Temperature, however, is not the only condition effecting efficiency of light production. Different substances have different powers of radiating light when heated to a given temperature. Carbon, which is black, is not as good a light radiator as a number of white substances which are also refractory. A piece of burned lime can be heated up with an oxyhydrogen flame to a point of intense incandescence, forming the familiar lime-light, which was the first really high power light-source to be used.

The high efficiency of the Welsbach gas burner and the Nernst lamp is due to these two facts, that is, the use of a white substance having a higher light radiating power, and a means of raising it to a high temperature.

Substances in the form of a gas or vapor are more efficient light radiators than solid bodies. The light of the sun is due to incandescent gases; among artificial lights the Mercury Vapor Lamp, developed in this country by Cooper Hewitt, and the so-called Vacuum Tube Light, of Moore, in which air is the luminous substance, are the only practical examples of the use of luminous gases as light producers; both of these are highly efficient.

That which is used to produce light we may call the Luminant; the luminants in common use are artificial and natural gas, acetylene gas, electric current, petroleum, and various oils and fats.

Bodies which give out light are called Luminous Bodies; those which do not, Non-luminous; a non-luminous body upon which light falls becomes an Illuminated Body.

Substances which allow light to pass through them in such a way that objects may be clearly seen through them are Transparent, such as window glass, and water; those which allow light to pass through, but scatter it in such a way that objects cannot be seen through them, are Translucent, such as ground glass, and milk; those which do not allow any light to pass through are opaque.

Light has two properties—Intensity and Composition; or in more familiar terms, brightness, and color. Brightness, or intensity, is a quantity, capable of measurement (it is easy to conceive of one light being twice as bright as another); color, however, is a quality, and therefore incapable of measurement.

SUMMARY.

DEFINITIONS.

LIGHT: The cause of the sensation of vision, or seeing.

ILLUMINATION: Light used for the purpose of making objects visible.

LUMINANT: A substance or means used for making artificial light.

LUMINOUS BODIES: Those which give out light.

TRANSPARENT: The quality of the body which allows objects to be seen through it.

TRANSLUCENT: The property of a body which allows light to pass through in a diffused form.

OPAQUE: The quality of a body which does not allow any light to pass through.

INCANDESCENT: Emitting light.

TEMPERATURE OF INCANDESCENCE: The temperature at which a body gives out light.

PRODUCTION OF LIGHT.

Light is produced only by means of heat.

Efficiency increases with temperature, and depends upon the surface of the body emitting it.

Carbon is not as efficient a radiator as lime and other white substances.

Gases are more efficient radiators than solids.

PROPERTIES OF LIGHT.

The two properties of light are: Intensity and Composition.

Intensity, or brightness, is the power of the light to produce illumination.

Composition determines the color effect of the light.

The Cooper Hewitt System of Mercury Vapor Lighting

By C. H. Vom Baur.

To say that the mercury vapor lamp is not applicable for general use on account of its color, is doing it an injustice; for who will define the term "general use" in the sense which it is meant here? We have not yet seen the mercury vapor lamp light up art galleries, nor department store counters, but where is there an enclosed arc lamp that will not disturb the blues, as the mercury vapor limp does the reds? Incandescent lamps give a well defined distortion to the red and orange colors. It is so long ago though now since the incandescent was first introduced that we are well used to its pleasant color distortion, while we are quite unused to the unexpected color distortion of the mercury vapor lamp.

Every day brings this new tube light into a new field. Where it was first only used in photographic studios and printing establishments on 110 volt direct-current circuits, it is now used to illuminate central stations, even on 600 volts D. C. and gas houses with 25 cycles and 440 volts A. C. Foundries and machine shops, silk and cotton mills are among its largest users. Terminal stations, freight yards, specialty factories and shipping rooms come close behind. Automobile garages, barns and stables use them largely. For general office work and drafting rooms they have no equal. In one space of 6,500 sq. ft., 9 ft. 6 in. high ceiling, seating 161 clerks, fourteen 300 c.p. lamps, using no reflectors, give a splendid illumination, varying from 12 foot candles to 9.2 foot candles on the desks, with a power consumption of 24½ amps. at 110 volts D. C., or 2.7 kilowatts.

Figure 13 shows a machine shop. The picture was taken entirely by the Cooper Hewitt light, the iron shutters of the room being closed. It is easy to note the general evenness of the illumination with the absence of glare, together with the easy shadows and the searching quality of the light as it shines on either side. The lamps were about 15 feet apart, giving a distribution substantially the same as indicated by Figs. 1, 2 and 6.

Figure 12 shows a drafting room illuminated by Type K lamps. The same qualities are noticeable here. The contrasts of light and shadow being even smaller. The halation in both of these pictures is a minimum, indicating the absence of glare.

Figure 11 pictures an erecting shop first floor, equipped with two 300 c.p. lamps. The exposure was much too long, being 15 minutes, hence the halation. This picture was taken at night, and shows plainly that it is a splendid light to work by.

Dr. D. T. Day (*American Magazine*, April, 1906), lays great stress on the difference between the glare and the glow of different artificial illuminants. Starting with the light having the highest glare and going down the line to the light having the highest glow value, he gives—acetylene, arc, gas, candle, incandescent Welsbach, Nernst, oil, osmium, tantalum, Cooper Hewitt.

Dr. Day says the Cooper Hewitt is the "largest and mildest glowing surface." Thus the Cooper Hewitt has the highest glow value, that is to say it is a "soft light." This helps to make it easy on the eyes. In this connection Dr. C. P. Steinmetz pronounces it the only "harmless artificial illuminant." (Elec. W. & E., Feb. 10, 1903).

In all of these places illustrated, and wherever the lamp is in general use, the color objection is soon waived. This is readily understood from the remarks of a large manufacturer when he said they were "giving excellent satisfaction." Another manufacturer

said: "The mercury vapor lights have been burning every working day for a period over a year and have never given us the slightest trouble. We have failed to discover any diminution of light or any increase in the amount of current consumed."

With regard to its effect upon the eyes—a much mooted question—a newspaper printer says: "They are giving perfect satisfaction. The light is *steady* and well diffused. It is much less trying to the eyes and much more satisfactory to the men in every way than any light I know of for the purposes to which we have put it."

A printer using eighty-eight 300 c.p. lamps said: "Our employees prefer it because of its softness and *steadiness,* as it does not affect their eyes detrimentally."

The great natural diffusion of tube illumination, due to its low intrinsic brilliancy, and the large area of the light-giving source, make it particularly applicable for spaces which are partly obstructed by posts, belting, or other vertical or horizontal objects. The ability of the light to shine through the interstices of the leaves of trees is particularly noticeable. A 45-inch tube will illuminate both sides of a field lathe and not throw any perceptible shadow beneath it. In short, one Cooper Hewitt lamp will "shine around a corner," which would take two lamps of any other kind to accomplish the same purpose.

In making subsequent tests on mercury vapor lamps in various laboratories with different types of photometers, with greater and lesser length of photometer bars, and varied standards, it was found after repeated tests that the candle-power varied as much as 7% above and 15% below the normal value determined several years ago. Recent tests made in a Paris laboratory (See *London Elec.,* July 20), show the candle-power to have varied as much as 46% with different length of photometer bars. In the light of this larger discrepancy the results tabulated here are well within practical limits, as in no case was the test lamp farther than 48 feet away from the photometric screen.

The following values (that is, the maximum light perpendicular to the axis of the tube), for Cooper Hewitt Lamps have been established at 300 c.p. for the 21-inch or Type "H" D. C. lamp, taking 192 watts; at 425 c.p. for the 28-inch or Type "C" A. C. lamp, taking 275 watts, and at 700 c.p. for the 45-inch or Type "K" D. C. lamp, taking 385 watts, all on 110 volt circuits.

As the c.p. varies so much with the conditions and due to the light source being a comparatively large surface, the law of inverse squares hardly holds. Yet the results with reflector, giving in percentages of the maximum light of the naked tube, will always give satisfactory results, when figuring the candle foot intensities or other problems. The luminous effect if anything, is greater, as the values so used were obtained with a regular photometer, the law of which does not strict-

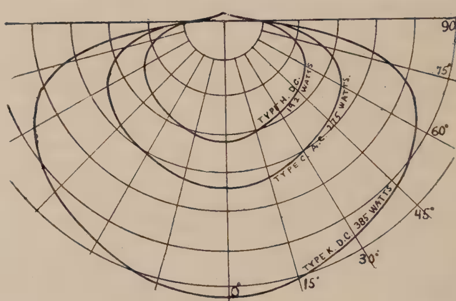


FIG. 1.—DISTRIBUTION IN A PLANE PERPENDICULAR TO THE TUBE.

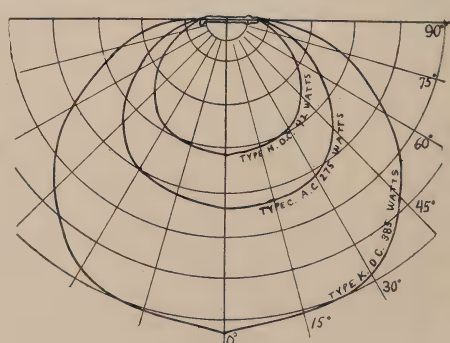


FIG. 2.—DISTRIBUTION IN A PLANE THROUGH THE AXIS OF THE TUBE.

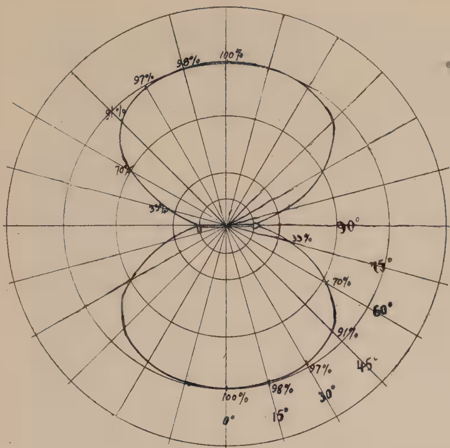


FIG. 3.

ly apply for long tubes as has been found by several investigators.

The curves (Figs. 1 and 2), show the intensities in two positions of the vertical plane. One position (Fig. 2) is taken parallel to the axis of the tube, and Fig. 1 is taken perpendicular to the axis of the tube. The results of two curves in the vertical plane as shown in these figures is not sufficient to afford conclusive mean values. In order to determine the exact mean spherical reduction factor, a much more exhaustive test would have to be made. These curves, however, via the Rousseau diagram, are correct within 5%. The tests showed the following:

The light perpendicular to the naked tube is constant at 100%.

The reflector is shaped as indicated in Fig. 1 and Fig. 4, having a white matt enameled surface with its vanes set at 132°.

The percentage variations of the Type "C" and Type "K" lamps differ but little from the above.

Figs. 6, 7 and 8 are the Rousseau diagram and Figs. 1, 2 and part of Fig. 3 with the addition of the mean of the two positions in the vertical plane. These means are respec-

TABLE I. (See Figs. 3, 4 and 5.)

TYPE "H" LAMP, 21″ LONG, 1″ DIAMETER.

Figures are percentages of maximum light of naked tube.

	Naked tube. Parallel to axis.	Naked tube. Mean.	With reflector. Perpendicular to axis.	With reflector. Mean.	With reflector. Parallel to axis.
0° (Nadir)	100%	100%	208%	208%	208%
15°	98″	99″	203″	202″	201″
30°	97″	98.5%	190″	192″	194″
45°	91″	95.5″	180″	171″	162″
60°	70″	85%	162″	139″	116″
75°	33″	66″	123″	98.5″	74″
90° (Horizontal)	About 9″	About 54%	About 10″	About 10%	About 10%

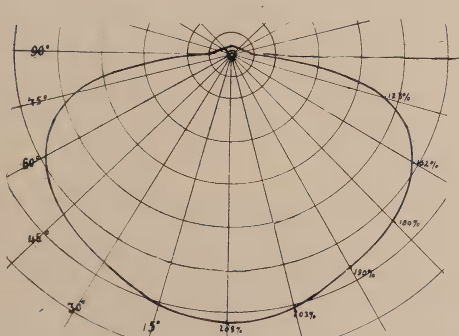


FIG. 4.

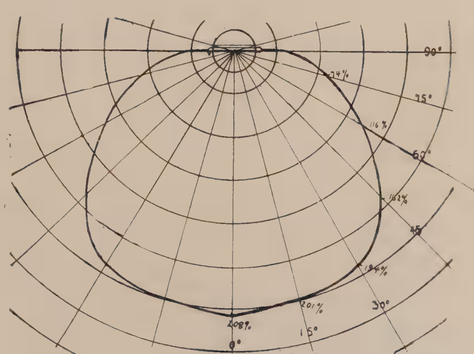


FIG. 5.

tively marked HBA, CBA and KBA, and are the resultants of HA and HB for the Type "H" lamp. The other two resultants of Figs. 7 and 8 are similarly determined. The HA, CA

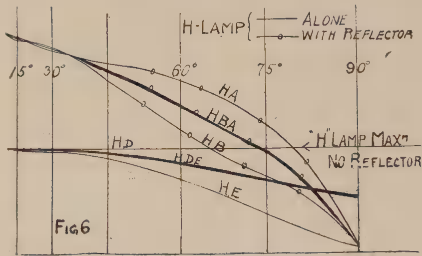


FIG. 6.—ROUSSEAU DIAGRAM, TYPE "H" LAMP.

and KA curves of the Rousseau diagrams correspond to the three polar diagrams of Fig. 1. In the same way, the BH, CB and KB curves correspond to the curves of Fig. 2. The mean of the two Figs. 1 and 2 is not shown polar diagramatically, and varies but little from either position as seen from the figures of Table 1. Fig. 9 is the graphic representation of the true comparative values of the three lamps via the Rousseau diagram.

In comparing Fig. 9 with Figs. 1 and 2, it is seen that in Fig. 9 the candle area varies directly as the area subtended, whereas in the latter figures, if the curves were perfect circles (which they approximate), they would

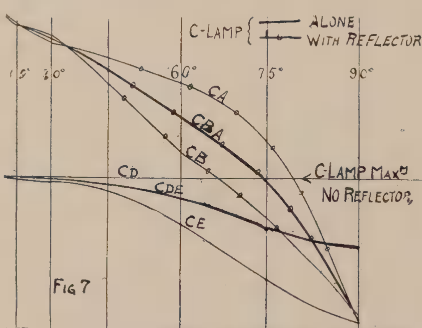


FIG. 7.—ROUSSEAU DIAGRAM, TYPE "C" LAMP.

vary as the square of their diameters. In other words, the area enclosed by the Type "K" lamps of Fig. 1 is about 5½ times as large as the areas of the Type "H" lamp curve, while

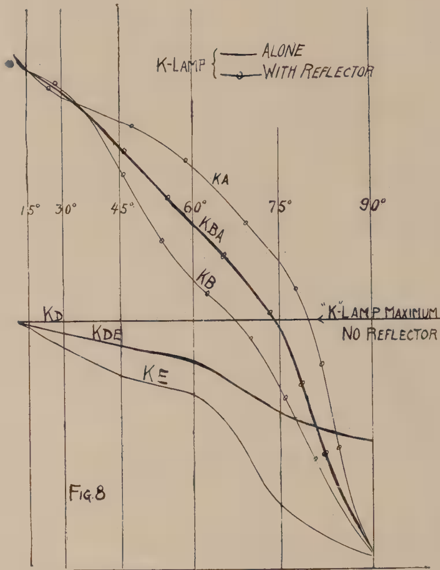


FIG. 8.—ROUSSEAU DIAGRAM, TYPE "K" LAMP.

when looking at Fig. 9, the Type "K" area is only about 2 1/3 times as large as the Type "H" curve area, which latter proportion indicates the correct candle-power intensities of the two lamps.

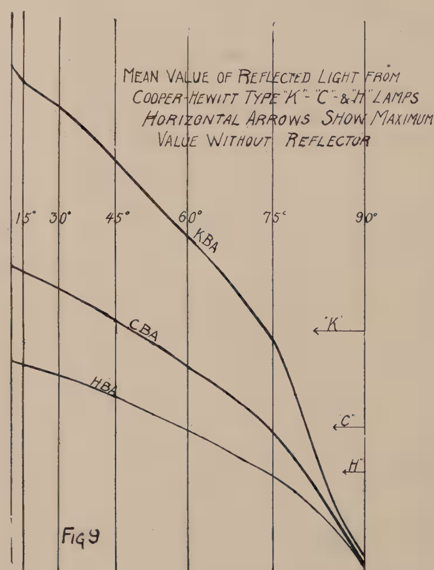


FIG. 9.—ROUSSEAU DIAGRAM, SHOWING COMPARATIVE VALUES OF "H," "C" AND "K" LAMPS.

DRAUGHTING ROOM. ILLUMINATION BY COOPER-HEWITT LAMP.

In referring to Fig. 6, one can see at a glance what the probable spherical reduction factor is to be, and also the hemispherical reflector factor. The straight horizontal line HD indicates the maximum candles of the naked tube. The curve HDE subtends an area very nearly proportional to the spherical candle-power. In the same way, the curve HBA subtends an area corresponding very nearly to the reflected hemispherical candle-power. The various tests showed the following, corrected to 110 volt circuits:

TABLE II.—TYPE "H" LAMP, 192 WATTS.

Efficiency.	Watts per candle.
Spherical reduction factor...... = .82	.73 to .91
Maximum naked tube..........	.60 to .75
Hemispherical reflector factor.. = 1.30	.46 to .58

The A. C. Type "C" lamp is a little less and the D. C. Type "K" lamp is a little more efficient than these figures of Table 2. The average absorption of the reflectors was 19.5%. It is a commendable fact that the mean quantity of reflected light at the 75° zone is very nearly equal to the maximum light of a given naked tube (See Fig. 9.) The variation of the mean reflected light is comparatively slight throughout the five useful zones, and decreases but 47% from its highest point at the 75% zone.

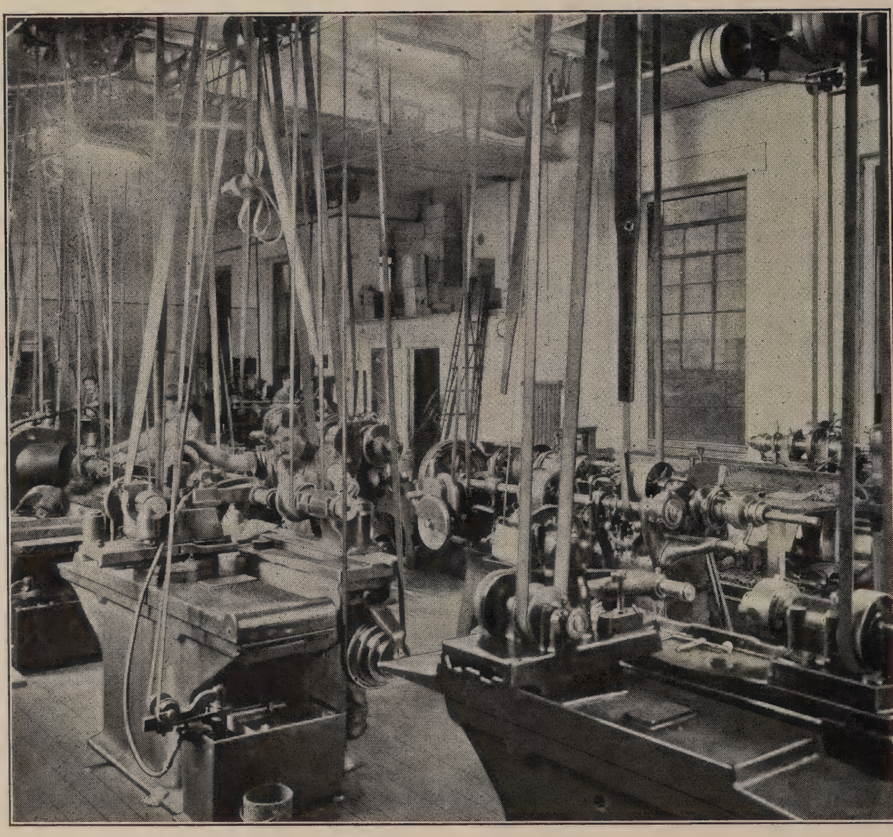
The lamp outfits are very easy to install. They are easily put up on any wooden or metal ceiling, are readily suspended from girders or I beams. With a little experience they are put up as readily as an arc lamp, the wiring being identically the same. The Types "H" and "K" lamps may be run on 110 to 220 or 600 volt circuits direct current, while the Type "C" lamp is for alternating current for frequencies between twenty-five and one hundred thirty-three and the usual com-

mercial low tension voltages. The alternating and direct-current lamps are not interchangeable.

The life of a tube averages 4,000 hours, or practically a working year of 12 hours, and is guaranteed for that time. The cost of a tube is so low that the maintenance per annum is as low or lower than that of an enclosed arc lamp, and further, because tubes have lasted over 16,000 hours in commercial practice, and then only been broken accidentally.

Another feature of the lamp, in connection with its great *steadiness,* is that it cannot take more current at any time at or near the normal voltage due to the insertion of an automatic current regulator, commonly known as the "ballast." This is a thin iron wire in a hydrogen container. With rising voltages on the line, the current tends to rise on the circuit. A rise of 10% in its voltage only allows an increase of 4½% in current.

In other words a rise in potential from 110 to 121 volts only allows a rise in current from 3.50 to 3.66 amperes. For decreasing currents the ballast action is not quite so pronounced; yet the decrease in per cent. is about the same for voltage and current. The 10% voltage increase on a pure ohmic resistance would cause a rise of current to 4.35 amperes or about 25% instead of only 4% with the ballast. On the other hand, a 10% decrease of potential would drop the current to 2.60 amperes or 25% instead of 10% with the ballast. The slight current fluctuations affect the c.p. but little, the variation for 10%



MACHINE SHOP. FROM PHOTOGRAPH TAKEN BY THE ILLUMINATION OF COOPER-HEWITT LAMPS.

A DARK BASEMENT MADE LIGHT. PHOTOGRAPHED BY THE ILLUMINATION OF THE COOPER-HEWITT LAMP.

increased voltage being about 3½%. This characteristic applies equally well to any direct or alternating current lamp.

Compared to the incandescent lamp, which varies 6% in its c.p. for 1% variation of voltage, the smaller or 1% variation in c.p is very marked for the 10% variation in voltage for the Cooper Hewitt Lamp. (See Trans., A. I. E. E., May, 1906.) It follows then that the incandescent lamp is seventeen times as sensitive in its candle-power variation as the Cooper Hewitt Lamp, due to voltage alone, under these conditions.

The enclosed arc lamp is steadier than either the open arc or the flaming arc lamp, at constant voltage. With unvarying potential the incandescent is inflexible in its constant candle-power, thus showing its superiority over any of the arc lamps. When the pressure commences to vary, its fluctuation consequently affects the arcs more than the incandescent. With the mercury vapor lamp *sixty times as steady* as the incandescent under the same conditions, what must be the relative steadiness in the luminous flux between the arcs and the mercury vapor lamp?

THE ILLUMINATING ENGINEER

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THE TRAINING OF ILLUMINATING ENGINEERS

We are in receipt of a letter from one of the leading lighting stations on the Pacific Coast, of which the following is an abstract:

"Our company is very anxious to engage the services of a young man, who has had experience with illuminating engineering, and thought that you might be able to put us in touch with a suitable person. We would desire a young man who is well grounded in illuminating engineering, who is a good talker and of good appearance, and who could meet the architects of the city and our various customers and advise them with regard to the placing of lights and the illumination of buildings, in general. In addition, we would require that he be well up in the motor business, so as to take charge of the canvassing for motors. He should be able to indicate engines and be well versed in the costs of generaing power for isolated plants, and be able to advise our customers regarding the proper methods of installing motors, etc., to secure best results.

"We have a very good opportunity for a young man here, as this city is growing very rapidly, and we have worked up a large power business, now having a connected load of over 10,000 h. p.

"The young man in question would be expected to act as assistant to the contracting agent, and would advise him on all technical matters."

This letter furnishes indubitable evidence that Illuminating Engineering is now a recognized profession: but where will one go to find an Illuminating Engineer? The few who have assumed the title have done so by virtue of such knowledge as they have been able to pick up by special study and research of their own direction, and experience gained in practical work. This small number of self-made Illuminating Engineers are mostly employed by large companies who use their talents both for their own and for their customer's advantage; a few others are using Illuminating Engineers as a side issue to other branches of engineering.

A demand for professional services can usually be satisfied by applying to a scientific or technical school, especially in cases like the one referred to in the letter, where theoretical training alone is all that is required as a beginning; but in the present case, this source is entirely unavailing. So far as we are aware, there is no school or college in the world at the present time that is giving any systematic instruction in illuminating engineering. As the demand for such engineers has arisen, however, it is likely that the technical schools will not be long in recognizing the need, and preparing to supply the demand.

It will, of course, not be contended that an extended course, ending in a special degree, would be justified at the present time. That the subject, however, should form one of the required studies in the courses of electrical engineering, and architecture, cannot be logically denied. This is particularly true with the schools of architecture. While the electrical engineer may devote his entire attention to numerous branches of the subject which have no connection with illumination, the architect meets the problem in every case which he undertakes.

Assuming the need of such instruction to be admitted, the question arises as to what should be included in a course of Illuminating Engineering. The basis of such a course, like that of other engineering courses, will naturally consist of a knowledge of mathematics and physics. As sufficient

knowledge in these branches is commonly included in all scientific courses, they need not be specifically included in this course. In addition to the course in optics, as ordinarily required, however, additional study of light in relation to the eye, and the ways and means of its measurement, would naturally form one of the important subjects. The physical construction and physiological action of the eye should form another of the important theoretical subjects. The production of luminants, including electricity, gas, acetylene, etc., should be sufficiently set forth to enable the student to obtain an intelligent idea of the general elements of cost entering into their production, as well as the conditions determining their quality. Methods of testing their quality should likewise be given careful attention. This would include the ordinary testing of electric currents, and the testing of illuminating gas for candle power and heat of combustion.

The principles of construction, of the various kinds of electric and gas lamps, and their comparative merits and demerits, for different classes of illumination is a subject of no mean proportions at the present time, and is constantly growing in complexity and importance; there are exceedingly few engineers who are thoroughly familiar with both gas and electric lamps, and capable of passing judgment upon the proper place and use for each particular kind. Following this would naturally come a study of the various accessories, such as reflectors, globes, shades, etc.

The subjects which we have thus far included pertain only to the utilitarian side of the question; and it would be quite possible for one to be thoroughly familiar with all of them, and use them with consummate skill and judgment, and still make a complete failure in many cases of Illuminating Engineering. If Illuminating Engineering is less exact and technical than other branches of engineering, it requires for successful practice a degree of skill and judgment along lines which engineers have no need to follow. In this respect it partakes more of the nature of the architectural profession, in which artisanship, *i. e.,* structural art, forms quite as important a feature as the mere knowledge of mechanics necessary for carrying out the forms of construction.

Artificial illumination is always one of the most obvious, not to say obtrusive, features of the building or location in which it is placed, and the question of making it sightly can in no case be entirely ignored, and in many cases becomes of paramount importance.

It may perhaps be urged that this field belongs to the architect or decorator. If so, then the architect or decorator must familiarize himself with the principles of illuminating engineering in order that the desired results may be arrived at in the end. It may not be necesssary for the Illuminating Engineer to be held responsible for the entire decorative or æsthetic effect of a system of lighting; he must, however, be held to account for the illuminating results obtained, and it is simple matter for the architect or decorator to so pervert the plans of the Illuminating Engineer as to entirely nullify the final results which were aimed at. Thus, while the entire initiative in the way of decorations should not be assigned to the Illuminating Engineer, he should at least have a veto power upon the work of the decorative artist to such an extent as to insure that the final optical results which he has laid out shall not be overthrown. The Illuminating Engineer must, therefore, be familiar with the elements of decorative art and structural art, and, furthermore, must have some of that indefinable quality known as "taste."

The list of subjects as enumerated can certainly not be abridged without curtailing the knowledge actually necessary for the treatment of ilumination as a branch of applied science and art; and both in their scope and subject mattter are of sufficient dignity to compare favorably with other special

courses given in the leading technical schools and universities.

It is also apparent that to properly pursue this course, special laboratory facilities should be provided. An Illumination Laboratory should offer facilities for studying the special problems involved, such as reflection and diffusion from walls and ceilings of different kinds, the measurement of illumination in various ways, color effects of different light sources, and in general the reproduction, as far as possible, of the various conditions met in actual practice.

The student who should have pursued such a course of study, and familiarized himself with all the principles involved so as to be able to put them into intelligent use, would undoutbedly have spent as much time in the acquisition, and would have acquired as great a number of special facts and theories, as did the first students who assumed the title of Electrical Engineer, and be as much entitled to receive a special degree.

ILLUMINATING ENGINEERING AS AN AID TO SELLING

The letter from the lighting company previously quoted, points out another important fact to which we have called attention in previous issues, namely, that a knowledge of Illuminating Engineering is an exceedingly useful, if not an absolutely necessary part of the equipment of the successful salesman of luminants and lighting apparatus. It may be stated as an axiom in salesmanship, that the salesman must know his "line" better than his customer knows it. No amount of "personal magnetism," glib conversation, funny stories, nor that variety of salesman's talk colloquially termed "hot-air," can take the place of a thorough knowledge, and a simple, clear exposition of that knowledge, of the particular line in question.

A buyer is naturally, and by training, a sceptic; he assumes that all the "tricks of the trade" are being exercised upon him, and is therefore on the defensive, lest he be "taken in" by the specius argument and glittering misrepresentations of the salesman. Ignorance, like murder, will out. Imitations of knowledge are always apparent; and the salesman who makes statements which he cannot back up, or demonstrates, is in a helpless position as soon as such statements are challenged by his customers.

The customer whose illumination is unsatisfactory, and whose bills, as a result, are considered excessive, is not likely to be placated, nor inclined to add to his lighting installation as a result of any "clever," "snappy," "up-to-date," catch-penny "literature," drummer's "yarns," or calendars that have eluded the vigilence of Anthony Comstock.

The simple replacing or rearranging of some of the lamps, the substitution of more efficient reflectors or globes especially suited to the needs, and the reducing of a few lamps from 16 to 8 c.p., thus showing a reduction in current consumption along with the improved illuminating effect—and this can usually be done—will do more to win the confidence of the customer and lead to ultimately larger returns than any number of the numerous wiles which are commonly considered to constitute salesmanship.

As we have previously stated, the trained Illuminating Engineer at the present time is an exceedingly scarce article. The demand heretofore has not been sufficient to create a supply. To meet this deficiency, it would be well worth while for a central station or gas company employing any considerable number of solicitors or contract agents to set up a little school of Illuminating Engineering of its own. Such employees could meet at stated times, and receive instruction in the general principles of the subject. The various problems and difficulties met with in the line of their duties could also be brought up, and discussed by employee and employer. In this way much valuable information would be brought out, and the liability of soli-

citors running into personal fads and notions be avoided.

Central stations and gas companies, moreover, are not the only interests to which such a course would be valuable. The manufacturers of lamps and accessories, both of gas and electricity, would find the salesman who could actually give prospective customers valuable information on lighting problems would soon command a trade that would in the aggregate, repay for such instruction many times over.

Illuminating Engineering is not a mere accomplishment, nor theoretical knowledge having no commercial bearing, but is a practical and sound business proposition, and one which cannot be ignored by the lighting industries without in the end resulting in financial loss.

REDUCTION IN THE COST OF ILLUMINATION

The past year has witnessed a remarkable renaissance of efforts directed toward reducing the cost of producing light, and improving the methods of utilizing it for illumination.

The Luminous or Flaming Arc Lamp produces light at a cost not exceeding one quarter of that required by the enclosed arc. The Magnetite arc produces light at not more than one-half the cost of the ordinary arc, and it seems not unlikely that it will develop a still higher efficiency. The Tantalum Incandescent Lamp has an efficiency of practically twice that of the old form of carbon filament lamp, and it is asserted upon good authority that the Tungsten Lamp, on the same principle, will give double this efficiency, *i. e.,* have an efficiency of one watt per candle. Filling the gap between the arc and incandescent lamps, the Mercury Vapor and Vacuum Tube systems may be considered, both of which have reached the practical stage, and have efficiencies far in excess of the present incandescent lamp. Thus throughout the entire field of electrical lighting, it is conservative to assume that a given amount of light can be produced at the present time with one-half the cost that was required by the best devices known a few years ago.

The reduction in cost of light-production by electricity must necessarily change to some extent the relations of electric and gas lighting. As we pointed out in our last issue, gas light has held its own by reason of its great superiority in cost of production. The halving or quartering of the cost of electric light, however, might very seriously change this advantage heretofore held by gas. The limit of cost of gaslight, however, has by no means been reached. It is a well known fact that very much higher efficiency may be obtained by using either the gas, or air supply, or both, at a higher pressure than is now the practice in this country, and gas lamps based upon this principle are being largely installed for exterior lighting in England.

Several attempts have been made to establish "intensive gas light," as this system is called, in this country, but so far as we are aware, without commercial success. It does not follow, however, that this apparent failure of many improvements in light production that they have been known and put into practical use abroad a number of years before being commercially successful in this country. Furthermore, there seems to be no reason why the price of gas to consumers should not be reduced without entailing a corresponding loss to producers. We can see no sufficient reason for the manufacture of illuminating gas, *i. e.,* gas giving a luminous flame, under present conditions. To be sure, ordinary flame gas burners are still numerous, but there is no reason why they should not all be supplanted with incandescent burners or electric lamps. A gas capable of producing the best of results with incandescent burners,

and suitable for all heating purposes, could undoubtedly be made and delivered at a good profit at a cost very materially below that at present charged for illuminating gas; and even though the percentage of profit were reduced, the increased use of a cheaper gas for fuel purposes would bring larger aggregate returns to the producing companies. Towns having a supply of natural gas, which is nonluminous, get on perfectly well with it for both heating and lighting purposes, and why should not a similar gas made artificially answer all purposes equally well?

It has long been recognized that in the use of light to produce illumination excessive waste has been the rule, rather than the exception. This fact, together with the increasing complexity of uses for artificial light, as well as the greater number and variety of light sources and accessories, has at last given rise to an established profession, namely, Illuminating Engineering. While exact figures as to the economies accomplished by Illuminating Engineering are few, from cases with which we are familiar, in which actual results have been obtained, as well as from the possibilities of numerous cases investigated, it is perfectly safe to say that a reduction of 25 per cent. in the cost of illumination is a low average of the saving that can be thus affected.

When the improved light sources that are now on the market, or in process of development, are utilized to their very best advantage by the skill of the Illuminating Engineer, illumination of a superior quality will be produced at from one-quarter to one-half the present cost. While greater economy in the production of illumination is therefore inevitable, there is no likelihood of any one particular form or source of light obtaining a monopoly of even a single department of the illuminating field. The total result will be a larger general use of artificial light, and the production of more satisfactory illumination.

PHOTOMETRY AND ILLUMINOMETRY

Advancement in science necessitates the invention of new words, as well as new processes and devices. Photometry was a strange sounding word a century ago. Illuminating engineering was a practically unheard of phrase 10 years ago, and Illuminometry has yet to be recognized as a word in good standing among scientific terms.

Photometry signifies the theory and practice of measuring *light*. The purpose of producing light artificially is to secure illumination; that is, to so utilize the light produced that objects may be seen thereby. Light and Illumination are thus two entirely distinct quantities. It is possible to produce a large quantity of light with an exceedingly small quantity of illumination. It is safe to say that 90% of the acknowledged waste of light is due to a misconception, or ignorance of this fact.

While processes of measuring light have been brought to a reasonably refined point, the methods of measuring illumination are yet in a crude state. It was but a comparatively few years ago when the c. p. of a lamp meant practically nothing to a great majority of users. There has been great progress in this direction of late, so that the term has become comparatively familiar, and has a definite meaning to a comparatively large number of people.

The term, foot-candle, however, is practically meaningless at the present time to the layman; but the time is coming in the not very distant future, when, instead of paying for luminants, or even for light, a user will pay for illumination. This will necessitate accurate and ready means for measuring illumination.

The great difference between photometry, and measurements of illumination or illuminometry, are brought out in the investigation of the Moore lamp, which was reported in our last issue.

Correspondence

FROM OUR LONDON CORRESPONDENT

Street Illumination by High Pressure Gas Burners.

Some months back a scheme was formulated and carried out for lighting certain districts of the city of London; and we have had frequent opportunity of seeing how admirable the work of illumination has been done in one of the districts known as Queen Victoria street and Queen street—very important thoroughfares in the heart of London, extending from one of the "Bridges" over the Thames, known as Blackfriars Bridge, to the Mansion House, the official residence of the Lord Mayor. In this district there have been installed 45 high-pressure gas lamps of 600 candle-power each, under a contract entered into by the city authorities with the well-known firm of illuminating engineers, James Keith and Blackman Company, a firm who were very early in the field with high-pressure gas.

The district is supplied with gas by the premier gas company in the United Kingdom, the Gas Light and Coke Company, who have an annual output of 22,342,009,000 cubic feet of gas. The company's mains, in this particular street, are carrried through a subway, one of them being a high-pressure trunk main along which gas is sent at a pressure of from 10 to 20 inches. The lamps are placed at distances of about 55 yards apart, on each side of the road; on the diagonal line the distance would be about 33 yards.

The illustration, Fig. 1, gives a good idea of the style and appearance of the lamps; the lanterns are made entirely of copper with specially designed windproof tops, which are surmounted with the city heraldic insignia; in the base is fixed a mercurial governor, in order that the gas shall be supplied to the burners at a constant pressure of 10 inches. Each lamp carries two 300 candle-power burners fixed on a special mercurial anti-vibrator; the two burners are controlled by one of Keith's patent flashing bye-pass cocks. Each of the high-pressure gas lamps consumes 20 cubic feet of gas per hour; the lighting hours in the city of London number 4,300 per annum, and the charge made by the Gas Light and Coke Company for each lamp is 12

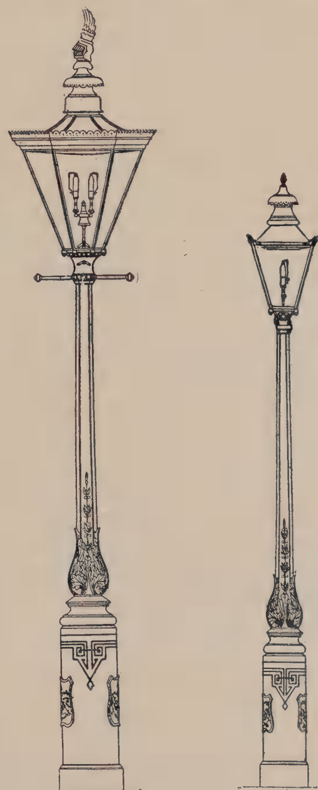


FIG. 1. FIG. 2.

LAMP POSTS AND LANTERNS USED WITH THE GAS BURNERS.

pounds ($57.00) per annum; the price includes supply of gas, lighting, extinguishing and maintenance.

The second lamp, shown in Fig. 2, is the one adopted and installed in

what is known as the Billingsgate Area—or London's fish market on the banks of the Thames, between the Taver and London Bridge. The lamps here are 32 in all—thirty of 300 candle-power, and two of 900 candle-power each. The larger number of lamps carry single burners, and are placed from 16 to 20 yards apart; the 900 candle-power lamps in use are of the same pattern as those in use in Queen Victoria street and are placed in the center of the refuges in part of the market. The work has been done by James Keith & Blackman Company. The gas company's charge for the 300 candle-power lamps, inclusive, is 6 pounds, 12 shillings ($31.68) per lamp per annum.

Another district, Fleet street, the hub of the newspaper world, has been lighted by high-power lamps, but of a more moderate character, adapted to the normal lamp columns, each lamp having two incandescent burners. In all 34 lamps have been installed, giving an effective light of something over 5,000 candles; these lights are all near the pavement-level; the total cost per annum is 312 pounds ($1,497.60).

These are examples of modern illumination as applied to public streets and are in every way satisfactory. Fleet street is a brilliantly lighted thoroughfare, with many blazes of light from arc lamps, flame arcs, clusters of incandescent burners, Sunbeam and Nernst electric lamps, etc. It has become the "vogue" here to have outside lighting, and many of the newspaper offices have lamps fitted with either electric light or gas burners of great intensity. The tailors' and jewelers' shops, of which there are many, outvie one another in brilliant outside lighting. In these days much attention is given to "dressing" shop windows; to such an extent is this carried out that the whole of the window casing is fitted from floor to ceiling, so that it is necessary to illuminate the whole area of the window on the outside. For these reasons it is difficult to judge of the effective illumination by means of the burners already described, at least so far as Fleet street is concerned.

The Queen Victoria street district is of quite a different character, and after office hours, say six o'clock, all the premises are closed and the passers-by are entirely dependent upon the street lamps. The effective lighting here is excellent, and the meeting of the extensive rays at the diagonal point can be clearly noted; to use a hackneyed term, the street is "one blaze of light" from end to end.

From Germany comes a novelty for workshop lighting in the form of a hook lamp; reference to the illustration will make its usefulness apparent. The lamp hangs upon a rod provided with a number of hooks opposite each other. The rod, as is shown, hangs inside a bracket consisting of two tubes upon which the hooks rest. A flexible tube is used from the distributing pipe and to the lamp may be suspended at any distance from the work in hand, whilst the slotted space between the two tubes of the bracket permits considerable lateral motion.

It is now possible to classify the principal systems of illuminating gas, and the following descriptions practically cover gas lighting systems up to date.

Low Pressure.

Gas is supplied at the ordinary pressure, ranging from 1.5 to 3 inches water gauge pressure. Under this system it is obvious that with the same initial pressure better results can be obtained by the use of modern incandescent burners than with the old flat-flame burner which was in general use until within the last ten years.

High Pressure.

This system differs from the low pressure in the fact that power is needed to supply gas at a greater pressure than the normal pressure in the distributing mains. There are several compressing machines on the market which may be used; the power to drive them may be gas, steam, water or electricity. The burners may be the or-

dinary incandescent adjusted to suit the different qualities of gas and the pressure at which it is to be consumed; still the best results will be obtained by using a burner specially constructed and regulated for the working pressure of the apparatus. As an alternative to too high pressure gas may be considered the high-pressure air system, in which case the usual conditions are reversed. Compressed air obtained by mechanical means at a much higher pressure than that of the gas supply, is made to pass through a very fine calibrated nipple where it meets the gas supply. When this high pressure air supply is applied to the head of the burner a very hot flame results, similar to a blow-pipe flame. A very slight variation of the pressure of the air supply, or blast, will considerably effect the flame intensity and consequently reduce lighting power.

Recuperative.

With this system the lost heat from the incandescent burner is utilized to increase the temperature of the mixture before ignition. The air is admitted at the top and passed over the intensifier which has been already heated externally by the waste gases, and passes down the tube provided for the purpose to the inlet at the bottom of the burner, and here the mixing takes place at a temperature of about 130° Fahr. The light given by the so-called recuperative lamp is certainly an improvement on the ordinary low pressure.

Self-Intensifying.

There are many lamps which are classified as being self-intensifying and oftentimes recuperative lamps are placed under the same head. The more generally accepted idea has been to have a long shaft, cylinder or chimney, where the difference in the temperature between the top and the bottom, when the lamp was burning, is so great that the equalizing effect causes an inrush of air through the lamp. This current, or draught of air, at first sight may appear to have quite an opposite action to the recuperative lamp but, the cool air is of greater density, and more highly charged with oxygen, resulting in a much more rapid mixing of the gas heated and cold air and should insure more complete combustion. These self-intensifying lamps have become very popular and give a splendid duty per cubic foot of gas consumed. They also have the very distinct advantage of requiring no mechanical appliances for either increasing pressure or reducing an accelerated air supply.

The enormous increase in the sale of gas supplied through automatic meters is exemplified by the following figures, which were given us by the engineer of one of the gas undertakings in a London suburb—Lottenham and Edmanton. In the three months ending December last the amount collected in bronze coinage in penny-in-the-slot gas meters was 12,274 pounds, 10 shillings, or 2,939,400 pennies (2 cents each). The number of these meters in use, at the end of the year, was 23,556. In the seventeen days from December 4th to December 23rd, an average of 17 to 22½ cwt. of bronze coinage was taken to the bank every day.

Improved Processes of Mantle Manufacture.

Many improvements are being made in the manufacture and preparation of mantles for incandescent gas burners. The Plaissety Manufacturing Company have succeeded in making a mantle which is of the stocking form, but which is so made that it can be sent out flat. It is very slightly coated—just sufficiently to accelerate the burning off; these mantles readily shape themselves when placed upon the "fork" and hang just over the head of the burner. It is claimed that they have three or four times the strength of the older form of mantle and that their resistance to vibration makes them specially suitable for street lamps, railway stations, factories, etc. There is practically no risk or dam-

age in transit; bulk and weight of packages are greatly reduced. There is little fear of crushing the mantle during the operation of attaching it to the burner; so altogether the new Plaisetty mantles are likely to become extensively used.

We also hear of non-collodionized mantles; these can be rolled or wrapped up very much in the same way as cotton wicks for oil burners. It has often been mentioned that the very fact of collodionizing a mantle has a detrimental effect upon the fabric and that the mantle does not give so good an illumination, at least as long as it would do if the collodion had not been applied. In burning off the flame emitted is a source of danger; many beautiful creations in silk

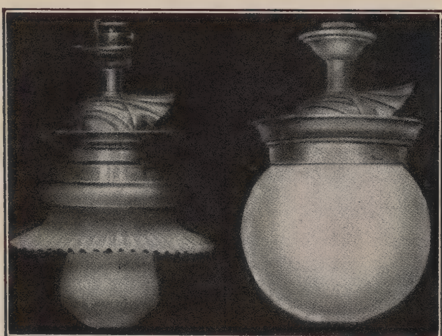


FIG. 3.—THE BLAND INVERTED GAS BURNER.

and lace shades have been destroyed through catching fire, and the offensive odor given off hangs about a room for quite a considerable time. The perfecting of a mantle and its non-stiffening by collodion is a very great step in advance and will be hailed with much satisfaction by the consumer and retailer.

Inverted burners have come to stay; they lend themselves to the artistic eye of those who desire to obtain efficient illumination without obtrusive and inartistic fittings. A new "inverted" has just been put upon the market—the "Bland," which we illustrate. The burner is of high efficiency and at 15/10 h. pressure with a consumption of 2½ cubic feet of gas per hour, an illuminating value of 56 candles has been obtained. With higher pressure, and a slightly increased quantity of gas, the duty is considerably greater. With 27/10h. pressure and 3 cubic feet of gas the illumination is 80 candles; with the same quantity of gas and a pressure of 7 inches a light is obtained equivalent to 125 candles. Upon examination of the lamp we found that the air enters vertically at the top and regulation is secured by an adjustable shutter. The nipple or burner has only a single hole, which is of oblong shape and inside the nipple there is fitted a piece of fine gauze. The mixing tube is fitted with a nozzle of magnesia. The mantle is not supported in the ordinary way but a small elongated bulb is fitted internally with a shoulder and upon this the supporting frame of the mantle rests. The nozzle of the burner merely protrudes inside the mantle and is not attached to it. In the general form of "Inverted" a brass support is slipped into the globe to carry the mantle. It will be noted that a deflector, above the burner, diverts the products of combustion away from both the air inlets and the burner chamber.

The illustrations show the construction generally; the glassware lends itself to a variety of combinations to ensure decorative effect.

CHAS. W. HASTINGS,
Ed. *Gas Engineers' Magazine.*

ORGANIZATION AND CONDUCT OF A NEW BUSINESS DEPARTMENT SUITABLE FOR CENTRAL STATIONS IN CITIES OF 50,000 POPULATION AND UNDER

BY J. M. ROBB.

Success lies in never tiring of doing, in repeating and never ceasing to repeat; in toiling, in waiting, in bearing and observing; in watching and experimenting, in falling back on oneself by reflection, turning the thought over and over, round and about the mind and vision, acting again and again upon it—this is the law of growth. The secret is to do, to do it now; not to look away at all.

Bishop Spalding's definition of success fits the organization and conduct of a new business department as though he had it especially in mind when he penned these lines. The ability to increase the sales of current must be as assiduously cultivated as you study the means of reducing costs and bettering your service, and there is no central station so small that it can afford to get along without a new business department.

There is a general tendency to believe that others accomplish their work with less effort than ourselves, and this perhaps is responsible for the lack of confidence some central station men have in their own ability to conduct a successful new business department.

The busiest manager or superintendent, if he will persistently devote a few minutes daily to increasing his sales of current, will accomplish results as amazing as they are gratifying when he reviews them. Do not let anything prevent your beginning your new business campaign at once. Start now. Don't wait for printed forms or to think out definitely how you will go about it. When you have made your beginning you will be astonished at the opportunities for new business that will develop in the most unexpected places.

Working a new business department is like popping corn. Your first efforts produce only a cracking sound, but no popped corn. If you stop now, your work is lost. But keep on; first one kernel pops and then another and another. Encouraged by these, more and more kernels pop until your popper fills as if by magic.

If, most fortunately for you, your business seems to be in the condition of the full popper, remember the unpopped kernels that are always found when the popper is emptied.

There are plenty of unpopped kernels of undeveloped electrical business in your territory which a little attention would convert into profitable income.

* This paper was awarded the third prize by the Coöperative Electrical Development Ass'n.

Naturally your first thought will be "How much money shall I spend to secure more business?" As the limit, up to which money can be profitably spent for this purpose, is in all probability beyond your means, your chief concern will be to use to the best advantage the largest appropriation you can get. Go slowly at the beginning. As a general rule, any expenditure for pushing your business will be beneficial, but there are great possibilities for waste. Hence the necessity for waiting, observing, watching and experimenting.

How shall you spend your new business appropriation? For solicitors? For newspaper advertising? Or for "direct-by-mail" advertising?

The most efficient results will be obtained by a combination of all these methods; newspaper advertising to awaken your public to the possibilities of electric service, make your customers realize your appreciation that your business is governed to the largest possible extent by the same principles applying to any retail selling business, and to prepare the way for your solicitors.

Solicitors to call upon your possible customers, answer their questions, argue away their objections and clinch their orders, as well as to investigate the troubles of your present customers; explain your methods of handling their business, and convince them that they are actually receiving full value for the money they are paying you.

And, finally, direct-by-mail advertising, to excite the interest of those possible users of your service your solicitor cannot readily reach; to back up his arguments with those he does see, and to keep alive his prospective customer's interest between his calls.

Each of the above divisions of business getting, properly handled, will produce excellent results, but the most effective work can be only done with a combination of all three.

Endeavor to handle your new business appropriation so that your efforts will be continuous. If you must choose one of the three methods above outlined, by all means employ a solicitor and make strenuous efforts to keep him permanently at the work.

SOLICITORS.

In picking your solicitors, pay the most attention to their ability to handle people.

For this work you must have salesmen, and no man who cannot handle people can ever be a salesman.

The gift of gab is not an essential, but the ability to talk convincingly is. Many a loquacious salesman spoils his work by talking too much.

Beware of the brilliant, sharp man, who works by fits and starts.

Dependability is of the utmost importance. The slow plodder who never forgets a point once mastered will soon distance the speedy man who quickly catches on, but just as quickly tires if his first efforts are not successful.

Persistency counts for more than dash. Few prospects are interested at the first call, and just as water constantly dropping wears away stones, so patient solicitation secures profitable business.

If you have, among your employees, a man who evidences selling ability, use him for a solicitor.

Your solicitor must, of course, thoroughly understand your business, but this does not mean that he must start with a working knowledge. If your man is a real salesman, he may be ignorant of the electric business at the start. A few days' coaching will fit him to begin your work, and every day after that will add to his knowledge. Some gas companies have made solicitors of their regular employees, in connection with their routine work, by paying them commissions on new business secured, with the understanding that the new business work would be pushed only outside of regular working hours.

Properly handled, this practice will produce results and it possesses the additional advantage of arousing the men's interest in pushing your business.

There is always danger, however, that the prospect of a commission will lead to neglect of some regular duty, and the practice is further likely to foment jealousy among the men.

An excellent way to pick solicitors is to advertise for salesmen and carefully study the applicants. You can soon pick out the effective men. The man who can't be earnest in advancing his own interests certainly won't make much headway in pushing yours.

In searching for soliciting material, do not neglect to consider how a woman can push your interests, if you can find one of the right sort.

Having picked your solicitors, take time enough to thoroughly explain your business policy to them. Discuss with them your rates, your contracts, your customs, and your rules and regulations. Make clear to them the distinction between profitable and unprofitable business. Teach them to think in dollars and cents, and give them enough data to enable them to estimate the cost of connecting any business they secure.

Take them over your plant and endeavor to make them appreciate the amount of work involved in rendering good service to your customers.

If possible, make a few calls with each solicitor, letting him do all the talking, and then coach him between calls.

If you already have one or more solicitors, they can assist you in training the new men, but it will be to your best interest to let the beginners receive their first notions of your methods of handling your customers from yourself.

Divide your territory into as many districts as you have solicitors, arranging as nearly as possible an equal division of business and residence territory in each district, so as to give each man an equal amount of possible business.

The size of your new business appropriation will determine the number of solicitors you can use. Some companies have profitably worked one solicitor to each 4,000 of population. Each central station man must determine the number of solicitors to employ from his own conditions.

Your solicitors are now ready to go after business, but your work in handling them has just begun.

It depends on you to arouse their enthusiasm to the highest pitch and to keep it there.

Have the solicitors report to you each morning as early as convenient and canvass their previous day's work. Have a little booster meeting to start the day. Have each man tell of the orders he secured yesterday, the prospects he developed and anything which helped him secure an order.

Encourage the men to discuess the business freely and to advance their criticisms and suggestions.

Be liberal in your commendations of good work and sparing of criticism, but criticise sharply when circumstances require it.

As often as possible, explain the operation of some appliance you are pushing. Demonstrate its good points and teach the men the arguments to down any objection that could be advanced by a prospective customer.

Use every means at your disposal to increase the men's knowledge of your business, constantly impressing upon them that any increase in their efficiency is to your mutual advantage. Note carefully any article in trade papers, etc., or any articles on salesmanship that will help your men, and specifically call their attention to them, asking the men to read them carefully and then tell you what they think of the matters discussed.

Have your men 'phone to you at noon, both to let them know that you are following their work and to advise them of any prospects which may have developed in their respective territory since morning.

Keep a blackboard record of each man's work brought up to date, to advertise to

1. SOLICITORS DAILY REPORT.

NAME ______________________ FOR DATE ______________________

CUSTOMER'S NAME & ADDRESS.	CONTRACT No	LIGHTING No 16's	No ARCS		POWER H.P.	SIGNS 16's	APPLIANCES	TOTAL LOAD	COST TO CONNECT	EST YRLY REVENUE	CASH PAID
						TOTAL	CASH REC'D BY				
TOTAL FOR THIS DAY.											
TOTAL WEEK UP TO THIS DAY.											
TOTAL MO. TO 1ST. DAY OF WEEK											
TOTAL YEAR TO 1ST DAY OF MO.											
TOTAL YEAR TO DATE INC.											

ELECTRIC COMPANY.

FORM I.

all the employees the work the solicitors are securing.

Have each solicitor turn in a daily report each morning, similar to Form No. 1, given herewith.

If any payments are collected, the amounts must be properly entered, footed up and receipted by your cashier, or whoever is authorized to receive the cash.

The daily, weekly, monthly and yearly totals make possible an immediate comparison of each man's work, both with reference to current results and to results obtained in any previous period.

This form should be printed on sheets in letter head size and put up in pads. The completed sheets should then be filed in a vertical file, where they give a complete record of each man's work.

You must train your solicitors to be old business retainers as well as new business getters.

They must realize that their own, the customer's and the company's interests are all bound together.

Turn over to them for investigation the complaints of customers in their territory.

Have them look up the customer's apparatus, reread his meter, explain to him the methods used in handling his business and make a vigorous effort to convince the customer that he has the same check on his purcnases of current that he has on his purchases of any other commodity.

Energy expended to convince customers that they are receiving full value for the money they pay you, is one of the most profitable means of securing more business. If your customers are made to realize that they are receiving their money's worth in service rendered, they will use your service much more liberally and be much more open to your suggestions for their use of more conveniences requiring additional current.

It is a mistake to pay solicitors solely a commission on the sales of appliances. This practice will surely result in sales of appliances to customers who cannot advantageously use them and will certainly cause much dissatisfaction and loss to you.

A flat salary is preferable, and some managers adopt the flat salary method because of the labor required to record the results of each solicitor's work.

The ideal method is a combination of a flat salary and a commission based upon the volume and value to the company of the sales of current effected by the solicitor, with a fine for business lost in the territory allotted to him.

One prominent gas company pays its solicitors a salary of $50 per month and a

commission based on results secured, which is determined as follows:

A pool is made each month, representing a certain sum for each solicitor employed.

The various kinds of business to be secured are classified and given an arbitrary value of a certain number of points. The greatest number of points is assigned to business requiring no additional investment to serve and to business corresponding to sign and power business.

From this the business is graded down to the lowest number of points for business which is simply renewal business, due to consumers removing from one location to another, and business requiring a heavy investment for a relatively small income.

To assist in the classification, the solicitor must report on a card the estimated cost of connecting the customer, as determined from a schedule furnished him in which are given the costs, as determined by the previous years' averages, of the various items entering into the total investment necessary to serve the new business.

He must also report an estimate of the first year's revenue from the new customer.

The ratio between cost of connecting and volume of sales is considered by the new business department manager in assigning the number of points to the business secured.

At regular intervals the solicitor's records are checked from the customers' ledgers, so that the tendency to overestimate the value of secured business may be offset.

A deduction of an arbitrary number of points is made for business lost in each solicitor's territory.

At the end of each month each solicitor's points are totaled and the percentage his total bears to the total of all the solicitors' points determines his share of the pool.

In this particular case the sum pooled for each solicitor is $25, making the average salary $75 per month per man. Some of the solicitors on this basis earn as much as $125 per month.

A better way is to determine what price you can pay for each kilowatt of new business secured, grading this price from a high rate for profitable business to a very low rate for business requiring a heavy investment, and no rate for unprofitable business.

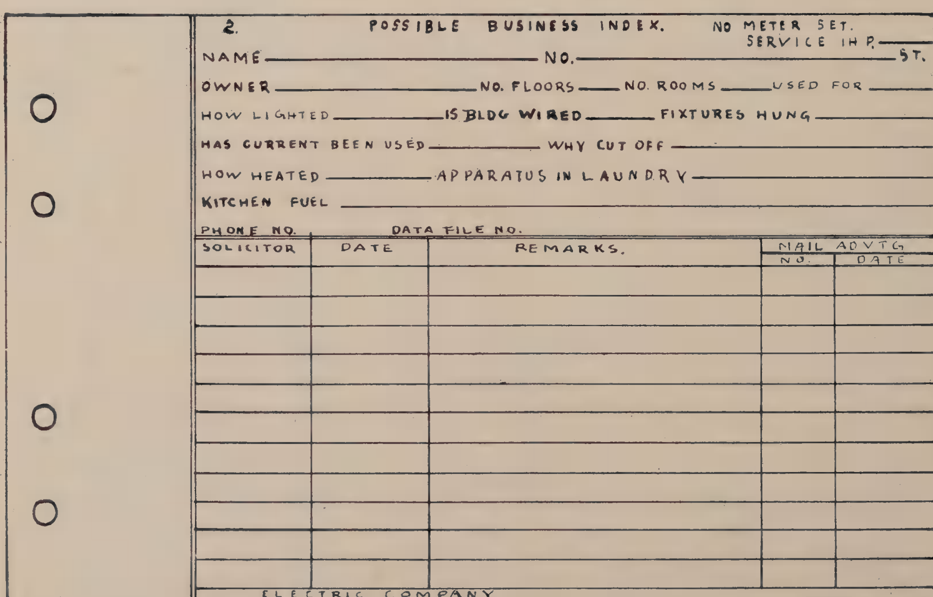
Then agree to pay the solicitors a commission at these rates for a year for all business secured, having it understood that any business lost in their territory shall be deducted from the commission at the same rates.

Such an arrangement is mutually profitable for both solicitor and company.

The business secured can be readily determined if the backs of the Possible Business Index sheets be printed as shown on sheet "A."

The solicitor should be required to turn in with each order the corresponding P. B. I. sheet on which he has noted what his order covers.

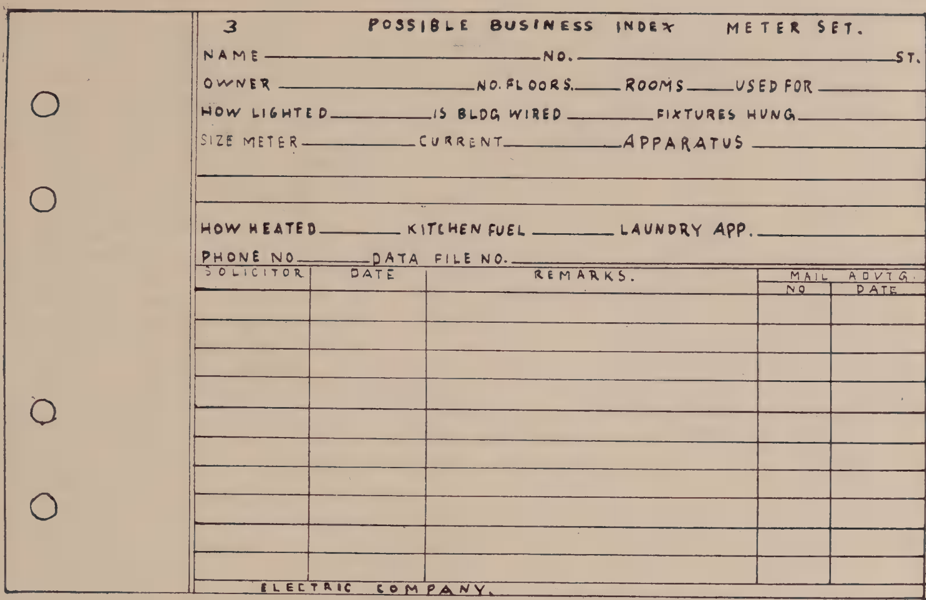
If the order represents a customer already connected, the amount of the customer's business for the year previous to


2. POSSIBLE BUSINESS INDEX. NO METER SET.
SERVICE IN P.
NAME ________ NO. ________ ST.
OWNER ________ NO. FLOORS ____ NO. ROOMS ____ USED FOR ____
HOW LIGHTED ________ IS BLDG WIRED ____ FIXTURES HUNG ____
HAS CURRENT BEEN USED ________ WHY CUT OFF ________
HOW HEATED ________ APPARATUS IN LAUNDRY ________
KITCHEN FUEL ________
PHONE NO. DATA FILE NO.

SOLICITOR	DATE	REMARKS.	MAIL ADVTG. NO.	MAIL ADVTG. DATE

ELECTRIC COMPANY

FORM 2.



3 POSSIBLE BUSINESS INDEX METER SET.

NAME ______ NO. ______ ST.

OWNER ______ NO. FLOORS ______ ROOMS ______ USED FOR ______

HOW LIGHTED ______ IS BLDG WIRED ______ FIXTURES HUNG ______

SIZE METER ______ CURRENT ______ APPARATUS ______

HOW HEATED ______ KITCHEN FUEL ______ LAUNDRY APP. ______

PHONE NO. ______ DATA FILE NO. ______

SOLICITOR	DATE	REMARKS.	MAIL ADVTG. NO	MAIL ADVTG. DATE

ELECTRIC COMPANY.

FORM 3.

securing the order should be entered on the P. B. I. sheet and also the monthly average for the year.

The sheet should then be filed in a secured business binder under the name of the solicitor securing the business.

Each month for the year following the date of the order, the amount of the customer's business should be posted to the sheets and the increased business credited to the solicitor at the agreed rate. Such an arrangement may be kept up with a minimum of work and may be modified to suit any set of conditions.

It would induce the solicitors to devote their efforts along channels most profitable to the company, and the deduction for business lost would insure their being old business retainers as well as new business getters.

Under such an arrangement the solicitor would have every inducement to make every effort to remedy complaints, and he would find it very unprofitable to waste his time selling appliances to customers who could not use them to their best advantage.

If the foregoing seems too complicated a method of handling solicitors, you would do well to reflect that the success of your new business department demands good men to carry on the work. You can secure the best work from good men only when you pay them in proportion to the results they secure for you.

Any plan which will increase the efficiency of your men in securing more business for you, is mutually profitable to every one concerned.

POSSIBLE BUSINESS INDEX.

One of the most necessary essentials of a systematic campaign for new business is a Possible Business Index.

Pope says:

"Index learning turns no student pale,
But it grasps the eel of science by the tail."

That expresses the aim of a Possible Business Index. It is to the conduct of a new business department what plans and specifications are to a piece of construction work. No two men will work up their new business data precisely alike. Where one will want a complete plan, setting forth every detail, another will be content with a free hand pencil sketch with a very few notes.

It is well to bear in mind that when a man goes hunting he must have a pretty definite idea of what he seeks. If you have in your new business campaign a complete index of the possibilities in your territory, you will waste less of your new business appropriation.

While cards are generally used for such an index, loose sheets 5" x 8" in size and bound in binders will be found to be far more useful, and, in addition, will give all of the advantages of a card index.

Some of the advantages over cards are as follows:

The sheets are larger, giving more space for useful data.

The sheets bound in the binders will al-

A	REPORT OF SECURED BUSINESS.			
NO	ST. NAME			SOLICITOR
DATE	ORDER SECURED FOR			
EST. COST TO CONNECT				EST. YEARLY REVENUE
REVENUE FOR YEAR PREVIOUS TO ORDER				KW-HRS AMT.
REVENUE SINCE ORDER				REMARKS.
	KW.HRS	AMOUNT		
JANUARY				
FEBRUARY				
MARCH				
APRIL				
MAY				
JUNE				
JULY				
AUGUST				
SEPTEMBER				
OCTOBER				
NOVEMBER				
DECEMBER				
TOTAL YEAR				
PREVIOUS YEAR				
INCREASE				
METER REMOVED				CAUSE
ELECTRIC COMPANY				

FORM A.

ways be found in their proper sequence, and, if necessary, can be removed from the binder as easily as a card from a file.

By using thin paper much more information can be filed in a given space.

By using a thin binder, it may be carried in the pocket, and in this manner the sheets are much easier to handle in the field than cards.

Forms 2 and 3 and "A" give a set of forms for a Possible Business Index. Form "A" is to be printed on the reverse sides of Forms 2 and 3. These forms are self-explanatory. The 'phone number is put in because often very effective soliciting can be done by 'phone. The data file number is to be used when correspondence or estimates, etc., accumulate in soliciting a prospect.

An envelope, large enough to contain all of the letters, estimates, etc., in flat sheets, is used, given a number and filed in your data files. The envelope number posted to the Index sheet gives quick reference to all of the data on file for the prospect.

Your Possible Business Index should contain a sheet for each house or prospect in your territory.

As your territory is extended put in a sheet for each house or prospect in the new territory.

Arrange your orders so that every meter set, remove or transfer order and every appliance order, will go to the person in charge of the Possible Business Index, so that it will be always up to date, and show a complete list of all electrical appliances you are supplying with current.

Remember that your Index is your guide for directing your fight for more business, and the more careful attention it receives the less effort you will waste.

Use different colors of paper to indicate the different classes of new business.

For instance, white paper to indicate a building where no current has ever been sold.

Yellow paper to indicate a building now being supplied with current. Make the sheet for this class of business show an itemized statement of the connected load.

Red paper for a building where current has been supplied, but, for some reason, has been disconnected.

Brown paper to indicate power prospects.

Green paper to indicate sign prospects.

Properly laid out and handled, the Possible Business Index will not only show the possibilities for business, but it will also show the amount of work done on each prospect, and when the business is finally secured, the index sheets can be used to keep a record of the business obtained by each solicitor. This is easily accomplished by noting on the sheets the orders to be credited to the solicitors and then filing them in a separate binder behind the name of the solicitor who is entitled to credit.

Then, periodically, the revenue from such business can be posted to the sheets credited to each solicitor and his income earning value is thus readily determined.

One of the best methods of starting your solicitors is to have them first go over their territory to make up reports for the Possible Business Index. In this manner the ice is more easily broken for a new man and he quickly becomes familiar with his territory.

Practically, at regular intervals, depending upon your local conditions, have your man check up the New Business Index and carefully make the necessary corrections.

If you are mailing matter to your prospects, this practice will not only save money in postage, but the moral effect upon your prospects will increase the efficiency of your new business department many per cent.

To assist in keeping your Possible Business up to date, give your solicitors credit for any business closed in your office, where the Index shows the solicitor has called on the customer within thirty days of the date of the order.

NEWSPAPER ADVERTISING.

Your new business department can be made to prosper without the aid of your newspapers, but, if you are wise and your appropriation permits, you will use them liberally and continuously.

Properly used, the newspaper will aid you in molding a favorable public opinion, and it will also secure new business for you. If it does nothing else, it will pay its cost in the increased efficiency it will produce in your solicitor's work. The newspaper adds a dignity to the house to house work of your men, which it would otherwise lack.

Use as much space as your appropriation will buy, but use it continuously. Don't splurge, unless your appropriation will stand it. Consider, also, how the average person scans his newspaper and you will realize that if you would have your advertisements noticed, they must be arranged so that "he who runs may read."

This means that your newspaper talk must be very, very short, sharp, pithy, incisive. They must stand out so that upon the paper being opened the advertisement at once catches the eye. Plenty of white space must be used to accomplish this.

The following excellent suggestion is taken from the *Electrical World and Engineer* of March 25, 1905:

"In preparing copy for newspaper advertisements the central station man must bear in mind that his efforts will not be searched for, except by himself. Neither can he, as a rule, use sufficient space so that his ads. will demand attention merely on account of their size. His problem, therefore, is to devise a means of insuring that his announcements will be read without resorting to anything bizarre or in bad taste.

"The plan here suggested has proved very successful, and anyone who adopts it will find that his advertisements will be the most prominent things on the pages which they adorn.

"It consists essentially of the purchase of a few fonts of a large, legible type to be used for your own announcements exclusively and differing from anything in regular use by the paper in which they appear. The type in which the advertisement here reproduced (but reduced to about 16 points) is set, is known as 28-point Caslon Old Style and has the reputation of being the most legible face ever cut. It can be used to advantage in two ways—first, as in the example given, in a few lines well spaced and surrounded by plenty of white space, and second, in two or three lines well spaced, as before, and followed by matter in small type. While Caslon Old Style is probably the best type for this purpose, there are other plain, bold and legible faces which can be used if the Caslon is pre-empted, though, as a matter of course, the results will not be so good if others are already using the same idea. When there is no competition in the lighting business, it is just as well in this style of announcement to omit all reference to name and address. It is 'different' and that in itself is good advertising. The following are offered as suggestions for 'copy.' Some of them are original, others have been culled from various sources.

"In papers of ordinary get-up as to their advertisements, it is surprising how impossible it is to look at a page containing one such as I have described without seeing it first, almost to the exclusion of everything else. Two fonts of type, costing about $8, will set any of the advertisements which can be set in the space commonly used."

In connection with the above, note the Macbeth lamp chimney ads. running in the magazines.

Give your newspaper talks direction. Select some person or prospect in your city, as nearly typical as possible of the prevailing type of people whose business you the going to get and address all your talks to him. It has been demonstrated in training street car conductors to call streets and stopping places, that announcements are much more easily understood if the conductor will direct his talk to some individual in the car, instead of just talking into space.

The same thing holds good in advertising.

You are going to persuade people to buy your service.

Very well. Point your arguments for some particular individual. Be direct; come to the point at once.

Use old-fashioned, plain English, the kind that says "Keep Out" instead of "No Admittance," or "Come In" instead of "Visitors are Welcome."

Use common sense. "The man who has

the truth in his heart need never fear the lack of persuasion on his lips."

It isn't necessary that you be able to write flowing sentences.

You have a story to tell. Imagine that you have your prospect up in a corner where he can't get away. Talk to him, but be brief.

Select some phrase to correspond with "Cook with Gas." Use it to head every advertisement and follow it up with a reason why.

Here are some suggestions.

LET ELECTRICITY DO YOUR WORK.

Get an electric iron. Then your ironing will be done with half the time and work. One will be sent to you on thirty days' trial if you 'phone to No. ——.

Get an electric warmer for baby's food. Then you won't have to chase downstairs nights to the gas stove.

Put up a porch light, with the street number on the globe, keep it lighted evenings. Let your friends know where you live, when they call.

How about the wear and tear that clothes wringer takes out of your clothes? An electric centrifugal clothes wringer will save it.

Ever hunt for things in your closets with matches? Electric closet lights are cheap fire insurance. Put them in now.

Do you use a chafing dish? See the electric chafing dishes at (your address).

Does your wife sew?

She certainly will appreciate an electric motor to drive her machine. Order one on trial.

Do you use power?

An electric motor will furnish it at less expense than anything else you can get. Telephone No. —— for particulars.

An electric fan will chase the flies out for you. Send in your order now.

Change your copy every day. This is important, and it will lead many people to look up your ads. to see what you will say next.

The more people whom you can get to think about your business, the faster will it increase.

Keep a scrap book file containing copies of every advertisement you run. If you will arrange your scrap book in the order in which your ads. appear, it will form an excellent means of checking your monthly newspaper bills.

Study every ad. that comes to your notice, in your endeavor to make your own ads. different from the others with which it is printed. The effort will pay big returns.

DIRECT-BY-MAIL ADVERTISING.

A campaign of direct advertising by mail will still further increase your solicitors' efficiency. Mail will easily reach customers who will never see a solicitor, or get to them at times when a solicitor's call would be considered an intrusion and resented.

Be chary, however, of your use of circular letters, and no not place too much faith in the selling power of multi-colored direct-by-mail stuff, artistically folded like a table cloth or bed sheet.

Business men to-day are busy. A sentence in black type on a plain postal will make an indelible, unconscious impression, where a choice collection of pictures on a square yard of wrapping paper will only produce an emphatic cuss word and a vigorous shove toward the waste basket.

The chief value of a circular letter is its personal appeal. Therefore is the necessity for its preparation with consummate care, to give it all the effect of a personal appeal to the reader.

Most circular letters are an abomination and unless you are sure of your ability to convince your man that it is his interest and business, not yours, that you are pushing, you would better stick to your postals.

If you do send out circular letters, enclose with each one an addressed postal (not a mailing card without a stamp), so that when your letter makes the desired impression the postal will be mailed before your prospect changes his mind in hunting for a one-cent stamp.

Be sure, too, that the postals are numbered for identification, for sometimes prospects mail cards, forgetting to sign them.

If you have an addressing machine, have the addresses of your prospective customers set up for it and arrange to keep it up to date. This will put you in position to effectively and quickly reach your prospects with any proposition you want to push.

Number consecutively the printed matter, mailing cards, circular letters, etc., that you have sent out; keep a scrap book with copies of all such matter and have the date and number stamped upon your Possible Business Index sheets. By tabulating the orders secured from each lot of matter mailed out, as shown by the entries on the Possible Business Index, you are in position to judge the effectiveness of what you are distributing.

CO-OPERATION WITH EMPLOYEES.

Do not end your work among your own men with training your solicitors. Work up the interest of every man connected with the company. Make them all see the possibilities that can be obtained if every man makes use of the opportunities for boosting the company's business that come to him every day.

Organize a progress club among the men, with meetings to be held monthly, or oftener, at which matters relating to the service, etc., can be discussed. Invite their criticism and study their suggestions. This

work will cost much in time and energy, but better results will be secured than can be contained in any other manner.

SALESROOM.

Your salesroom is a most important adjunct of your new business department.

First impressions count for everything with some people and for something with everybody. Your conditions will govern the quantity of apparatus you can display, but even if you show only a flatiron, you can show it, if you will, so that it will attract interested attention.

Don't neglect to have a glass case wattmeter connected up, so that you can demonstrate its operation any time.

Make use of the pamphlets, etc., that manufacturers of electrical apparatus will supply you for the asking. Everything helps.

CATALOGS.

Keep carefully filed, for reference, every catalog of current using apparatus you can obtain. Study your catalogs and have your solicitor study them. They will suggest endless applications demanding the use of current, many of which can be profitably used by your consumers.

APPLIANCE POLICY.

Make your selling prices for appliances bring you the same rate of profit a dealer would expect, but scrupulously put into advertising or soliciting every cent of such profit. This practice will encourage dealers to handle electrical appliances. Co-operation is what you need and the more people in your territory who can be induced to push electrical appliances, the better will it be for you. The practice of selling appliances at cost or less than cost, further has the tendency to confirm the popular opinion of the profits from the sale of the current. Then, too, many people measure the value of an article by its price and emphasizing the low price of what you are selling depreciates it to them.

Selling electrical appliances is more a matter of salesmanship than price.

Convince your customers of the value of your service. Create in them the desire to use it. It can be done by persistent work. Make your terms easy; small payments on long time and they will buy.

Offer every appliance you handle on trial long enough to thoroughly demonstrate its convenience and utility.

Follow up every appliance sold, with a careful inspection, to ascertain that it has been properly set and that its operation is thoroughly understood.

Push forward the merits of your service and leave price the last thing to discuss when you have shown how desirable and useful a thing your service is.

In exceptional cases, your margin of profit will permit you to arrange exchanges to secure profitable business you could not otherwise get, because of the customer's investment in concurrent consuming apparatus.

CO-OPERATION WITH CONTRACTORS.

Display in a prominent place in your office a wall directory of all the electric contractors in your territory.

Arrange to send them immediately any tips coming to your notice concerning wiring work, etc.

Keep in touch with your contractors, establish friendly relations with them and consider their criticisms and suggestions. Their co-operation is a valuable means of extending your business and is well worth your strenuous efforts to secure and hold.

Keep informed of the local work your architects have in hand and arrange for regular reports from the building inspector's office.

Knowing in advance of projected new buildings or remodeling work, you can furnish advance information to your friends, the contractors, and their self-interest in securing the work will make them effective solicitors for you.

PUBLICITY.

Make use of every legitimate means of securing desirable publicity for your company.

Establish friendly relations with the editors and reporters of your newspapers.

In most small towns, news items are not plentiful and much profitable publicity can be secured through tactfully acquainting your newspaper men of current happenings, such as contracts closed, contemplated improvements, etc., or handing them an occasional clipping describing some electrical appliance or some new application of electricity.

Should you, unfortunately, have an accident, prepare your own version for your papers. It will save them the trouble of writing it up and insure your public having the story as you want it told.

Remember, your business is bound to receive a certain amount of attention from the press. If you will make the effort, you can direct it to your advantage.

Make every piece of company property carry its advertising message. If there is no ordinance prohibiting it, put a permanent enameled sign on every one of your poles. You need not incur the expense of equipping all the poles at one time, but by buying permanent signs you can put them up on the instalment plan, without finding the expense too heavy a burden.

The benefit to be obtained by circulating a monthly bulletin among their customers and prospective customers is not properly appreciated by central station men.

Most electric men fully realize the bene-

fits their companies bring to the community they serve, but too many forget that there is no one except themselves to exploit these benefits to obtain the public apprecation they merit. Electric men, and gas men, too, for that matter, have too long been guilty of "hiding their light under a bushel."

Energetically pushing forward the many advantages of electric service, both to the customers and to the community as a whole will do more than anything else to disarm the hostile spirit too often manifested against central stations.

There is no one to do this save the central station men themselves, and no better way to accomplish it than the monthly bulletin.

The practice of advertising appliances on or with monthly bills for services is of doubtful value. The recipient of the bill is then in the least receptive mood for suggestions to increase his use of current.

The bulletin method is more costly to be sure, but it deserves careful consideration among your other plans for extending your business.

CULTIVATING POPULARITY.

Aim to be considered in your community as a public benefactor.

Give your wagons, tool carts, etc., especial attention. Paint them often and keep them clean.

Make your entire equipment carry the message of wide-awakeness and progressiveness to your community.

Use a portion of your new business appropriation for purchasing advertising space in programs for church entertainments, etc.

The space so purchased has little advertising value, but when the character and energy of the people behind church and charitable organizations is considered, the importance of securing their good will is apparent.

The amount paid in each case need only be a small one, but it is important that this matter be so handled as to build up a co-operative spirit and that your customers appreciate that you are anxious to lend your assistance to anything promoting the public welfare.

In this line of work, beware of the professional advertising scheme promoters.

If possible, arrange to loan cooking and other apparatus to church and charitable organizations free of charge, including current used. Stipulate, however, that a representative of your company shall superintend its operation to demonstrate the apparatus and to make use of any opportunity to promote your interests that may occur.

Your efforts along this line of work will certainly go far towards establishing your company solidly in the good graces of your customers and possible customers.

Never let any adverse criticism of your company, by any individual in your community, go unanswered.

Public service companies have so generally neglected to answer hostile criticisms that the public generally has come to consider that they have no answer.

Whenever you hear of a disgruntled individual, ascertain as quickly as possible what his grievance is, and either show him where he is wrong, or right his trouble. A few people you will find whom you cannot convince, but your efforts in this direction, persistently followed up, will bear rich fruit.

CONCLUSION.

You have doubtless noted that there is nothing new or radical in what has been advanced in this paper for the organization and conduct of a new business department.

These things have all occurred to every man who has given persistent thought to the work and will occur anew to the man who will engage in it later.

It would perhaps be difficult for any one man to follow all of the lines suggested, but every man doing central station work can, if he will, start with some one line of effort in this direction.

The start is the all important thing, for if the work be followed up, new ways and methods will be constantly suggested to the persistent worker.

Thoreau says: "I learned this * * * that if one advances confidently in the direction of his dreams he will meet with a success unexpected in common. If you have built castles in the air, your work need not be lost; that is where they should be—now put the foundation under them."

This also applies to the new business work.

Dream your dreams of satisfied customers lighting their homes, their factories and their stores with your current, driving their machines with your power; cooking their meals with your appliances; advertising their business with your signs. Then work, work day and night to make your dreams come true.

Work—everlasting, never tiring, patient, persistent work—that is the secret of a successful new business department.

Papers Read Before Technical Societies

THE MERCURY VAPOR LAMP

By Percy H. Thomas.

Extract from a Paper Presented to the Am. Inst. of El. Engrs.

As a lamp, the mercury vapor apparatus has a number of interesting characteristics. Its great efficiency, which in long tubes reaches 1/3 watt per c.p. (exclusive of resistance losses), is obtained only when run under the most favorable conditions; for example, only with the proper vapor pressure, current, and tube diameter. Mercury vapor is a much more efficient material for light production than most other gases and vapors whether used alone or mixed. The addition of atmospheric air, for example, to mercury vapor, even in very small quantities, increases the voltage on the tube very much, thus increasing the energy supplied.

The spectrum of mercury vapor is, furthermore, one of the most complete and usable gas spectra; it contains a variety of colors in substantially equal proportions, chiefly an orange-yellow, a yellow, a blue and a violet, with a smaller amount of a green-blue. The only portion of the spectrum not pretty well represented is the red, which, generally speaking, is the least desirable color. The mercury spectrum has proved to be excellent physiologically, and extremely well adapted to most mechanical processes. It is possible, of course, by the addition of other gases to add red to the spectrum, which may then be quite prominent, especially if means are taken to condense a portion of the mercury vapor. In general, however, these combinations of gases are more or less likely to deterioration and alteration, and have a considerably lower efficiency than pure mercury vapor. For most purposes the color would not be more desirable with the addition of red.

Light Efficiency: The efficiency of mercury vapor as a source of light follows a number of laws. 1, the watts per candle-power vary with the pressure of the vapor, having a minimum at a certain pressure, as shown in Fig. 1, which is from a test on a commercial type of lamp. 2, it is nearly independent of the current strength within certain limits, in this case it being assumed that the pressure, temperature, etc., are constant.

3. Superheating the tube, and consequently that portion of the vapor emitting light, seems to have little effect.

It will be seen by the curves in Fig. 1, on which is shown the normal lamp voltage characteristic, that is, the relation between current and voltage of the operating lamp, that the most efficient light giving point is at, or nearly at, the point of lowest voltage on this characteristic. This is fortunate, since for purposes of regulation this is a most desirable point to operate the lamp. Above this most efficient point the pressure of the mercury vapor increases rapidly, and while also increasing the candle-power it increases the voltage in the tube in still higher proportion. Below this point the voltage on the lamp rises, probably partly on account of traces of residual gas not exhausted in the pumping, which causes a great dropping off of the quantity of light and the efficiency. These residual gases are here more prominent on account of the lower mercury temperature and vapor pressure.

It is evident that the temperature of the

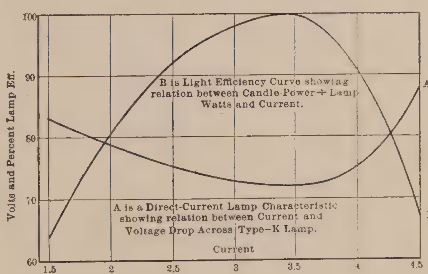


FIG. 1.

mercury electrode and the pressure of the mercury vapor resulting from a given current will depend directly upon the air temperature surrounding the lamp. In the commercial types of lamp, however, the actual change in efficiency from change in atmospheric temperature is very slight throughout the practical working range. This results from the flat form of the lamp characteristic near the point of 3.5 amperes, as seen in Fig. 1.

Lamps may be made for various uses with different diameters of light-giving tubes. The diameter most commonly used and suited to 3.5 amperes is 1-in., or a trifle less, in inside diameter. To give the same intrinsic intensity with other diameters the current should be varied in proportion to the cross section of the tube; that is, for a 2-in. tube we should require about 14 amperes. Since the voltage decreases as the diameter of the tube, and since at the same intrinsic brilliancy the quantity of light increases as the diameter on account of the larger surface, we should

expect double the light and double the energy consumed with the larger tube. It is found by measurement, however, that the larger tubes are somewhat more efficient, so that there is a saving of 20 to 25% on the efficiency for 2-in. over that of 1-in. tubes—inversely with smaller tubes and the appropriate currents. With smaller tubes, however, the difficulty of maintaining the negative alive becomes very much greater on account of the small current which, as already explained, is subject to momentary impulses tending to stop the flow of current.

There can be no one proper method of measuring the candle-power of a Cooper Hewitt lamp; first, on account of the fact that the color of the lamp is different from the color of any accepted standard, and because it is a spectral against a continuous spectrum; and secondly, because the light-giving tube is not a point, and the law of inverse squares does not hold except at very great distances. For commercial tests the candle-power of the lamp should not be measured at a great distance, since the lamp has a practical advantage over most other lights from its tubular form, which comparative advantage it

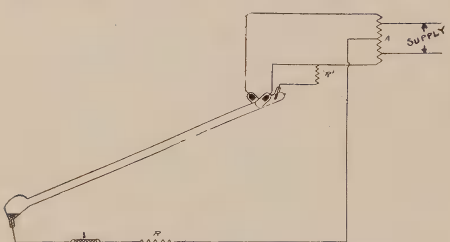


FIG. 2.—STARTING AND OPERATING CIRCUITS FOR TYPE C A. C. LAMP.

A, auto transformer; R′, starting resistance; R, lamp resistance; I, inductance.

would lose were the candle-power measured at a considerable distance. Where it is important actually to define the candle-power of these lamps, the particular method of measurement to be used must be specified.

Alternating-Current Lamp: The principle of alternating-current lamp is generally well understood by this time, the circuits being shown in Fig. 4. Referring to this figure it is evident that during one alternation, current is supplied from one-half of the transformer secondary through the lamp tube back to the neutral point, and during the other alternation by the other half of the transformer secondary through the tube to the same point, and that the choke-coil in the negative lags the current over the zero points.

The light from the alternating-current lamp is practically equivalent to that from the direct current, since in the light-giving portion of the tube the light is substantially direct current.

On 25 cycles, by providing a larger choke-coil in the negative than is necessary in the 60-cycle lamp, the natural tendency to flicker with the period of the 25 cycles is eliminated.

Starting: The method of starting in the type-C alternating-current lamp is an extension of that of the direct-current lamp and is of some interest. A small electrode or the pin. In the latter case the lamp as shown in Fig. 4, and connected to one of the positives through a rather high ohmic resistance. In starting, the lamp is tilted so that the mercury forms a continuous stream from the negative to the positive end and is carried by its momentum up around the inside end of the tube until it touches the pin which is placed on the top side of the tube. On account of the irregularity of the flow of the mercury it here makes and breaks contact with the pin a number of times, each time causing a breakdown of the negative electrode resistance, either on the column of mercury or the pin. In the latter case the lamp will go out at the end of the alternation. If, however, the mechanical break at the pin occurs during such an alternation that the mercury column is the negative the lamp will start to operate upon the pin, and that main positive electrode to which the pin is not connected as positive electrodes and the mercury stream as the negative. Then, on account of the starting resistance connected with the pin, the current will be immediately transferred from it to the corresponding positive, and the lamp is started. The lamp is then returned to its normal position and all the mercury flows back to the negative. If, now, there were no resistance between the pin and its positive electrode, and assuming the lamp to have been started during tilting by one of the breaks between the mercury and the pin, it is evident that if the mercury touches the pin again, that the lamp will go out, since for this instant the flow of current does not enter the vapor at all (on account of the metallic connection between negative and one positive.). That is to say, if it were not for this resistance which prevents current when once transferred to both main positives from being withdrawn by a subsequent connection between the mercury and the pin, the lamp would be started and put out and started again repeatedly. Only the last break between the mercury and the pin would count in starting, and we should fail to light the lamp more often than we succeed. As an actual matter of fact, lamps have been built which started practically every tilt, though the average commercial lamp is not expected always to light at the first trial.

SELENIUM AND ITS IMPORTANCE IN THE GAS INDUSTRY

By H. Raupp,

Read before the Association of Gas and Water Engineers, Mainz, Germany.

Selenium, it appears, is going to be of great importance in the gas industry, and I expect it to solve some problems that are now very interesting to us all, such as the automatic ignition of street lanterns. You find very little in literature regarding selenium and its wonderful qualities, and I suppose that you will be interested if I give you a short account of selenium and, by means of some apparatus, give you an idea how extensively and in what manner it will, without doubt, be employed in the gas industry.

Selenium has an atomic weight of 78.49; it occurs frequently in nature, but in very small quantities, wherefor it is classed with the rare elements; it belongs to the sulphur group, and its qualities are in many respects like those of sulphur.

Selenium occurs chiefly with the metals, as lead, sulphur, and mercury, as well as in iron and copper ores. It collects from these ores, used in the manufacture of sulphuric acid, on the bottom of the lead chambers. Here it was that Berzilius discovered it in the year 1817. We get it from these lead chambers in an amorphous condition as a red powder, which, on melting, changes into a black, glossy mass, resembling sealing wax; in this condition it is almost a non-conductor of electricity; but the wonderful qualities of selenium are brought out when this black mass is heated to 200° C., at which point it suddenly goes over into a metallic condition, having a lead gray color, a specific weight of 4.8, and a melting point of 217° C. Under the influence of light this metallic selenium is a much better conductor of electricity than in the dark, its conductivity being ten times as great in the light.

Of this quality we can make use by employing selenium in telephotography, in the telegraphic transmission of signs, in photography, etc.; but, aside from this, I shall demonstrate to you how selenium is likely to be used in the gas industry.

For practical purposes selenium is employed in so-called selenium cells. There you see (Fig. 1) a pear-shaped globe like that of an electric incandescent lamp; within this bulb is a porcelain cylinder about whose surface the selenium is wound in very fine threads. They are also made flat-shaped (Fig. 2) when used where the illumination is on one side only. They are manufactured in an excellent quality in Ruhmer's physical laboratory in Berlin.

In order to demonstrate to you how the light acts upon such a selenium cell I have constructed the following apparatus (Fig. 3). There you see a selenium cell, a dry

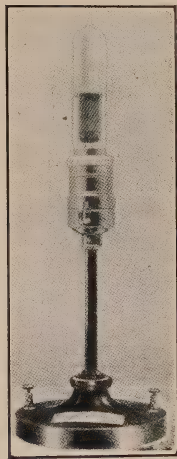


FIG. 1.

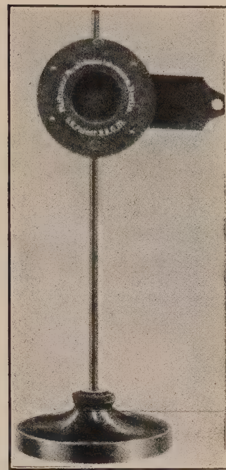


FIG. 2.

battery, and an electric bell on a relay; this relay has been so arranged that the bell does not ring when light falls upon the selenium; it only does so in the dark.

I have made use of this peculiar quality of selenium in the construction of an apparatus that may be used for testing gas, though to-day I can present it only in the form of a model (Fig. 4). The selenium cell constantly receives light either from a gas flame or from an incandescent lamp, and there moves slowly between flame and cell by means of clockwork a strip of white paper that has been soaked in a solution of lead acetate; it is enclosed in a gas-tight glass case, through which there is a steady flow of the gas to be tested. As soon as the cleanser gets dirty, that is to say, allows sulphuretted hydrogen to pass, the strip of paper turns brown or black immediately, the bell begins to ring, indicating that the process of cleaning is imperfect.

In this way we may get audible information that the gas is not clean chemically.

Through the indirect action of the rays of light I am able, by means of a selenium cell and a relay, to do all kinds of work. For instance, instead of ringing a bell as in above case, I can use the current of electricity as well for turning the gas cock of a street lantern.

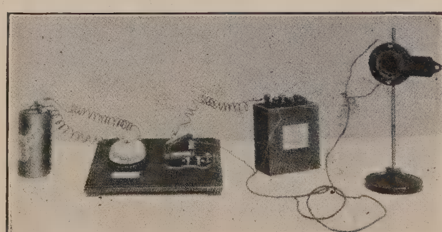


FIG. 3.

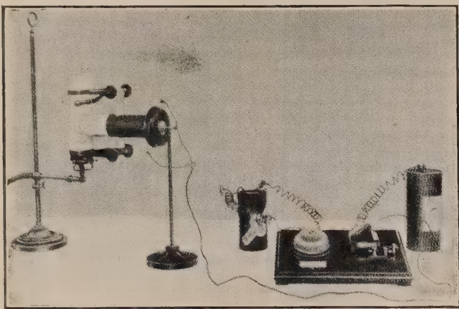


FIG. 4.

Here is a distance-lighter, a Welsbach burner with pilot flame, and the familiar electro-magnetic device for operating the gas cock, placed inside the jacket underneath the burner. I connect this incandescent burner with a selenium cell and a dry battery (Fig. 5), now, when light falls upon the selenium cell, *i. e.,* by day, the burner will not be lighted, but as it begins to darken, the dry battery will be automatically put in circuit, the cock opens —and there will be light.

To apply it to such cases it has to be placed on top of the street lanterns, to be out of the influence of its own light, as otherwise you will find there would be light and darkness alternately.

These automatic ignition devices of selenium are also of great importance for lighting bell-buoys, and have already been employed in this capacity.

There is another application which I should like to mention: Imagine a gas meter with two counters for the purpose of registering separately the gas used by night and that used by day, either moved by means of a clockwork, or by hand by means of a lever. The attempt has been made to move the works by means of an electro-magnet connected with a selenium cell in such a way that, as night approaches, the night register acts automatically, and vice versa, at dawn of day, the day register is put in action.

Finally, I should like to mention the old Siemens selenium photometer. You see

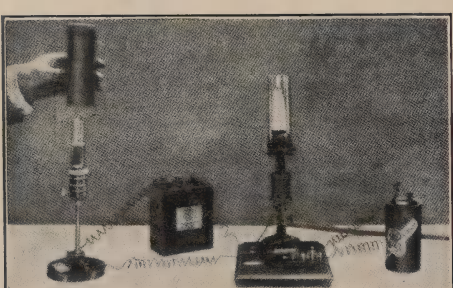


FIG. 5.

here (Fig. 6) a metal funnel, in the bottom of which has been placed a selenium cell; it is connected with a dry battery and a galvanometer. This funnel with selenium cell is substituted for the ordinary photometer screen (paper with paraffin spot). The selenium photometer works in the following manner:

The funnel is at first placed in front of a standard candle, and the deflection in the galvanometer noted, then the funnel is made to face the source of light to be measured, and then it is moved to and fro until

FIG. 6.

FIG. 7.

the galvanometer registers the same deflection as before. From the two distances then it is easy to calculate the intensity of the light.

In the employment of the old familiar photometer there was often a lack of precision, for one reason on account of the difference in eyes; this cannot happen where the selenium photometer is used, as the deflection in the galvanometer may be exactly read. Figure 7 is a selenium photometer of the latest construction, which may be used for all kinds of illumination; battery and tester are inside the galvanometer box.

MARINE AND VEHICLE LIGHTING

By Oscar F. Ostby.

Read before the National Acetylene Association Convention.

This is such a broad topic that I do not exactly know where to begin, and should I try to exhaust my subject I am afraid it would more than exhaust my hearers, so I will just mention a few of the many important usages on our highways of commerce on land and sea where Acetylene is fast gaining headway.

The lighting of yachts, power or sail, steamboats, tow-boats, and marine craft of all descriptions has always been a problem attended with great difficulties, both practical and economical. The same may be said for lighthouses, beacons, buoys, etc.

The larger power boats, as a rule, have been equipped with electric lighting plants, which are not only extravagant, but unreliable. Sailing vessels have been obliged to depend upon oil. The use of oil, aside from its inconvenience, inefficiency of illumination, and cost of attendance, will always be unsatisfactory and attended with dangers, to say nothing of its other disagreeable features. The adoption of electricity on power boats has overcome some of the objectionable features of oil lighting, but is by no means the solution of the problem. The space required for a dynamo and special engine and the necessity of retaining a certain pressure of steam in the boilers as long as light is wanted make such systems extravagant and inconvenient. The latter objection is sometimes partially overcome by the use of storage batteries, which take up still more valuable space, and are excessive in weight and uncertain.

There is a light, and only one, that never fails; that does not blow out; that does not break down; that is more brilliant than electricity and always steady; that requires no power, no machinery, no filling of lamps attended with fire dangers; that illuminates the most luxurious cabin, keeps bright and steady in the binnacle and running lights, operates the searchlight, and yet requires no more attention than occasionally ordering a new cylinder. It can be installed in a deep sea palace; it will equip the searchlight of a row-boat; from lighthouse to buoy it shines brightly through fogs that obscure other and more powerful lights. The light is from Acetylene, and with our Safety Storage System we are filling a long felt want.

You are all familiar with our System, and I will not enter into any detailed description. Briefly, it consists of cylindrical tanks of various sizes, from one that can be carried in a hand satchel to one 9½ feet long. The cylinders are packed with asbestos discs with an 80 per cent. porosity; the asbestos is saturated with acetone (a chemical very similar to wood alcohol), which at a normal temperature and 150 lbs. pressure absorbs twenty-five times its own volume of the gas, increasing the storage capacity of hte tank tenfold. When the pressure of the tank is released by the opening of a jet, the acetone releases the gas. A regulating valve, through which the gas passes after leaving the cylinder, regulates the pressure at the burners, so that it makes no difference how much gas there is in the tank or how many lights are being used, the flame and the pressure at the burners are always the same.

The yacht owner is quick to appreciate a good thing, but we are up against powerful interests, who are fighting for every inch of ground. Our competitors (I speak now for the whole Acetylene industry) appreciate the value and superiority of Acetylene more than any one else, and that where we once get a foothold they will eventually meet their Waterloo, for where we win it is always on our merits.

Our tanks vary in size from those containing only six cu. ft. of gas to our railroad cylinders with a capacity of 2,000 cu. ft. The size of the tank necessary for each individual boat is, of course, determined by the number and size of lights. As a rule we figure on supplying all lights for approximately one month, but where it is desired we make in installation that will take care of the lights for two or even three months and a whole season. The boat-owner appreciates what this means; he knows that there are no working parts to depend upon, and that whenever he wants light he can have it without trouble to anybody; he is paying for only the light that is used, and, last, but not least, he has the best light in the world at a lower cost than he could get any other. A very popular installation is what we call the double-cylinder system. As the name implies, it consists of two cylinders which are both connected up with the piping, only one of which is turned on at a time. When the gas from one is exhausted, or nearly so, the second is turned on; the first being exchanged for one fully charged, and thus keeping a full tank on tap at all times.

We are not only installing the safety Storage System on new boats, but in many cases as an auxiliary, and also replacing other systems on old boats. The superiority of Acetylene, where used as an auxiliary is so marked that the other illuminant, whatever it is, usually becomes the auxiliary.

We have equipped craft of all descriptions, including many of the best known yachts in the country, which carry the glory of Acetylene all over the world. Among the numerous installations made this season is a ferryboat, from which we have very favorable reports.

The piping of a boat for Acetylene does

not mean a general ripping up, for wherever possible the piping is run exposed and stained the color of the surrounding woodwork, so that after the job is finished the pipe has the appearance of a moulding. To connect up the binnacle, running lights, and searchlight we use a flexible rubber tubing.

Since the introduction of Acetylene for binnacle and running lights I'm sure St. Peter's work has been lighter, for there is as much difference between Acetylene and oil as there is between night and day, and we have yet to hear of the first case of an Acetylene running light blowing out in even the most severe weatehr.

For lighthouse, stake boats, buoys, etc., the high candle power and great penetrating power of Acetylene with small consumption again proves its great value.

The method of application is simplicity itself. Take the South Beacon at Sandy Hook for instance. As you have all read in the Acetylene Journal (I know we all read the Journal from cover to cover), we equipped that sometime ago, replacing oil. The gas is supplied from a railroad cylinder which is placed at the foot of the light and piping is run up the outside. In the light we use 3⅜′ burners, or in other words a total of onlv 1⅛ cu. ft. of Acetylene per hour. One tank supplies the light for about six months.

For breakwater and stake lights we use 16″ x 84″ cylinders, which contain approximately a three months' supply. We use the same lamp that has been used with oil by simply substituting an Acetylene burner. Boatmen in waters where Acetylene is used speak of it in the highest terms, and did they have their way no other would be employed.

For buoys we supply a tank with an available supply for 5,000 hours, which means a big saving, as every time a trip is made to some of the buoys in our harbors it means an expenditure of anywhere from $20 to $50.

The ideal illuminant for general railway lighting is one that may be produced at a central station, admitting of wholesale production, under single-headed management, and which may be transported throughout the entire system by some simple means without loss or danger, and which may be used for all purposes. There must be luminous intensity, simplicity in operation, and absolutely fixed light, exempt from atmospheric influences, wind, heat and cold, facility of being placed according to needs; no loss when the light is shut off; cleanliness, simplicity of maintenance, freedom from fire dangers, and explosion, and must be economical. The only illuminant that can qualify under all these conditions is acetylene, and on the railroad our System has proven its value, not only for car lighting, but for locomotive headlignts, tail lights, signal lights, station and yard lighting, etc., and in fact wherever a reliable light is needed.

Numerous roads throughout this country and Canada are using the System, and among these the D., L. & W., Canadian Northern, El Paso & Southwestern, and N. Y., N. H. & H. have already established their own generating plants.

ILLUMINATING POWER AND LIGHTING EFFICIENCY

By W. R. Herring.

Extract from a Paper Read Before the North British Association of Gas Managers.

During the past six years I have had occasion to devote very considerable time to investigating the phenomena which go to make up the efficiency of the light emitted by an incandescent burner, and have been directing an investigation into the causes which enable gases of various luminous flame values to render the same illuminating power when burned in the incandescent burner. I have had the opportunity of dealing with many grades of gas ranging from 12 to upwards of 30 candle-power.

It is generally believed that calorific power alone is to be the governing factor in the future; but my investigations warrant my saying that there is at least one other important factor to be taken into account at the present day when determining the value of a gas for lighting purposes. The visible luminosity and calorific power do not alone account for the results obtained when using the gas in incandescent burners, nor can the question of flame temperature alone account for the results. I have, however, no hesitation in saying that flame volume is a factor of even greater importance than calorific power.

It will doubtless have been noticed by many—particularly with flat-flame testing—that a considerable change in the volume of flame when burning at the 5 cubic feet rate is observable without affecting the luminous value of the gas. Then again a 25-candle carburetted water gas yields a much smaller flame than a 25-candle coal and cannel gas; and yet the flame temperature of the carburetted water gas is slightly higher than that of the coal and cannel gas. If, however, the volume of flame is insufficient to properly envelop every fiber of the mantle, then neither calorific power nor flame temperature can play its part and develop the highest degree of luminosity in the mantle.

Flame volume must be dependent upon the chemical composition of the gas, which I have found can vary very considerably for gases of the same luminous value and approximately the same calorific power.

A 16-candle gas containing 3.76 per cent.

of the unsaturated hydrocarbons compared with an average of 27.86 candle gas containing 9.26 per cent. contains two-and-a-half times as much of the unsaturated hydrocarbons. The illuminating power is only increased by 74 per cent., whereas the increase in the percentage of the illuminants present should have yielded, in the same ratio, practically 40-candle gas, or an increase of 148 per cent. This shows conclusively that a very much lower efficiency is obtained when burning the high-grade gas as a luminous flame.

Again dealing with the 15 to 16-candle series, it will be seen that there is 0.270 candle of illumination per unit per cent. of hydrocarbons present in the gas; and as we advance above the 17-candle quality the percentage of hydrocarbons necessary to yield one candle of illumination increases with the increase in the flame luminosity of the gas. British thermal units are again given for this series of tests, and British thermal units per candle; the latter column again showing a loss efficiency with the high-grade gas.

In carrying out these and other investigations I was often mystified by gases of comparatively low illuminating and calorific power yielding as good and sometimes better results with the incandescent burner than other gases of higher luminous value. Flame temperature naturally suggested itself as a solution of this problem, but did not satisfy me as being the only factor. I, therefore, again had recourse to our records, and prepared a statement which would show me the candle-power by incandescent burners in relation to flame luminosity and the calorific value of different gases.

From our books, therefore, we first abstracted the tests which yielded from 30 to 32 candles per cubic foot of gas when burned in the incandescent "C" burner. Against each of these results the candle-power ascertained by the argand burner is given in column No. 2, and the calorific power in column No. 3. In each case the incandescent burner was used to yield the highest efficiency, by a proper regulation of the gas and air supply. The candle-power of the gas was ascertained by a No. 1 metropolitan argand burner used to a 16 candle-power flame, and the calorific value of Junkers' calorimeter.

Incidentally, Table C also confirms what I have formerly stated as to the calorific power of the gas rising and falling with its luminous value, for it will be observed that the calorific power of the highest candle gas on the list is also the highest calorific power, and likewise that the .5-candle gas is the lowest calorific power.

TABLE C.

Statement Showing Candle Efficiency by Incandescent Burner in Relation to Flame Luminosity and Calorific Value.

"C" Incandescent Burner.			
Candles per Foot.	Consumption Per Hour. Cubic Feet.	Candle-Power of Gas. No. 1 Argand.	B.Th.U. Gross.
30.36	...	16.50	625.2
30	3.34	16.70	617.3
30.80	3.16	17.45	640.3
30.70	3.40	16.98	620.5
31	3.30	17.78	616.1
30.93	3.30	17.58	617.3
31.71	3.27	19.92	663.8
31.34	3.27	19.04	606.6
30.59	3.37	20.32	667.7
30.18	3.36	18.49	626.4
30.57	3.34	19.43	643.1
30.45	3.33	19.82	663
30.71	3.37	18.08	617.7
31.51	3.10	19.03	637.6
30.37	3.19	18.54	636.8
30.62	3.06	18.63	609.4
30.38	3.18	16.62	596.3
30.57	3.17	18.40	627.9
30.18	3.35	17.34	640.4
30.52	3.27	16.77	610.6
30.38	3.40	15.57	572.8
31.88	3.02	17.82	639.5
31.20	3.06	17.30	631.2
30.54	3.33	16.41	618.9
30.47	3.39	15.35	589.9
30.47	3.40	15.60	572.8
30.17	2.89	18.46	634.6
30.47	3.18	17.91	629.8
30.32	3.10	17.54	625.6
31.93	3.31	16.77	627.6
Gas and air regulated to yield highest result.	Consumption ranged between 2.89 and 3.40 cubic feet.	Gas burned to 16 candle-power flame and corrected to 5 feet rate.	

This statement gives some remarkable results, and goes a long way to challenge the present-day belief that calorific power alone is to be the factor governing the supply of the future. Glancing at the statement a moment, we find that a 15.35-candle gas of 590 B.Th.U. yields the same iluminating power by the incandescent burner as a 20.32-candle gas of 668 B.Th.U. A further glance at the second column will also show that gases of 15, 16, 17, 18, 19 and 20 candle-power luminous value all yielded practically the same degree of illumination per foot of gas when burned in an incandescent burner, using the same mantle with each test. Nothing could, I think, be more conclusive than this last statement as to the incorrectness of the policy of continuing to supply gas judged by its luminous flame value.

Review of the Technical Press

AMERICAN ITEMS

THE LIGHTING OF HALLS AND CORRIDORS OF LARGE PUBLIC BUILDINGS, by J. R. Cravath and V. R. Lansingh. *Electrical World,* August 4, 1906.

The general principles of this class of lighting are set forth by the writers as follows:

"The lighting of halls of large office buildings, hotels and public buildings is frequently one of the most difficult tasks met with in illumination work, for the reason that the artificial light must be used during the daytime when the halls are also partially lighted by daylight. The light from electric incandescent lamps, which must be used as a rule in such places, is likely to appear yellow and sickly by contrast with white daylight. The object to be attained in the lighting of long halls and corridors is to produce a general cheerful well-lighted effect. Here is a case where the lighting of the ceilings and side walls as well as that of the floor is important. Nevertheless, the color of the floor plays an important part in the general effect, and it is almost impossible to make a hall with a very dark floor appear well lighted. It is important to have the lights well distributed along the length of a long hall rather than to place large lamps or clusters at less frequent intervals. The reason for this is very simple. With chandeliers or clusters at infrequent intervals, the spaces midway between clusters appear poorly lighted by contrast with those portions of the hall near the clusters. The result is that this alteration of light and dark places makes the hall appear gloomy and poorly lighted even though the total candle-power of lamps may be sufficient. To light a long corridor well, therefore, it may be laid down as a first principle that small lighting units at frequent intervals should be employed.

"In the lighting of hotel corridors, off which there are sleeping rooms, the problem is somewhat different from that in office and public buildings and corridors off the lobby of a hotel, because the upper part of the corridor must be kept dark to prevent light shining through the transoms and annoying guests who have retired for the night and wish an absolutely dark room."

A number of examples of hall and corridor lighting are illustrated and criticised.

THE ILLUMINATION OF A WORKING OFFICE, by E. R. Roberts, E. E., Ill. Engr. *The Nernst Glower,* July, 1906.

The periodical appearing under the above title is published by the Nernst Lamp Co. as a trade bulletin.

While it is unusual to review a purely commercial publication, we believe that the character of such publications may be such as fully entitle them to such consideration. When articles based upon sound scientific and technical knowledge are thus published, the information contained is worthy of as much consideration as if it appeared in the "legitimate" technical journal.

The Nernst Glower has recognized the importance of illuminating engineering, and each issue contains one or more articles written from the engineering standpoint.

In the present, above mentioned, the following principles are laid down:

"In the lighting of working offices we would emphasize one point which is not usually conceded by the architect; viz.: the unfitness of bracket lights for this particular purpose. Their location usually makes them ineffective for either general or local illumination, and being directly in the line of vision, they are frequently more of a hindrance than otherwise in visual work. When local illumination is a necessity, a shaded incandescent lamp, mounted on the desk and to the left of the worker will prove more effective and economical.

"In a general office of light finish and fair dimensions whose floor area is, for example, 40 by 60 feet, and where flat top tables and desks predominate, superior results will be obtained with a system of general illumination entirely. Such a system would involve the use of medium sized units fitted with diffusing globes and mounted directly on the ceiling of ordinary height; a sufficient number of units being used to break up all shadows.

"In the small office, however, with roll top desks, placed back-to-wall around the sides of the room, the above treatment is not always applicable and individual desk lights will often be found necessary, unless the desks can be placed in such a position with respect to both the natural and artificial light sources, that the worker will never be handicapped by his own shadow. With desk lights properly located and

shielded, a moderate general illumination should also be provided.

"While the draughting room is to be classed as an office, yet somewhat different treatment than that outlined above will be required. Theoretically, one might be led to believe that a system of general illumination is the ideal for this purpose, yet actual experience indicates that, with a reasonable expenditure of energy, such a method is impracticable.

"The draughtsman as he bends over his work, requires the light to shine in under him rather than down upon him, and will usually welcome a system of individual lights in preference to an overhead system. In this particular case we are more than usually justified in respecting the wishes of the laymen."

The question of whether to aim at a sufficient general illumination to give the necessary light for writing at every point in the room, or whether to provide only a very mild illumination, and a special working lamp for each person, does not seem to have been settled, either by practice or theory. Both methods are in use, and in both cases those using the illumination seem to be equally satisfied.

Interior Illumination. By Seymour Storrs. *Light*, August, 1906.

The article is devoted practically to describing methods of using Inverted Incandescent Gas burners, in place of Electric lights, or Inferior illumination, among which are the following suggestions: The Incandescent Gas, Car Lighting, "Light," August, 1906.

A short descriptive and illustrated article showing the Dining Car, the light with the Pintsch Incandescent Gas Light.

"In a room to be decorated and illuminated, the gas-piping may be so curved as to follow the design of fresco or painted decoration, or a combination of bent pipe and fittings may be used to conform to the decorator's design. The sketch for this decoration having been drawn to scale, may be made of dual service, alike to the pipe-fitter and to the decorator-artisan.

"For the ceiling lights we suggest small inverted incandescent gas-lights on straight drops from the feeder-pipe. That pipe conforming in color as well as in shape to the ceiling decoration, and, as we have suggested, it should be made a part of it. The piping of the drops may be sheathed in a thin veneer tube of brass or of steel such as is made by the Shelby Steel Tube Co. This last material will take several styles of finish, and is inexpensive.

"For the side-lighting of the room goose-neck connections from a horizontal (wall) feeder-pipe, with either inverted or vertical burners, presents a convenient form of construction, since the wall-pipe well secured provides a picture moulding to divide the lower wall paper or decoration from that brought down the walls from the ceiling, and as well supplies a means of hanging light pictures.

"A neat manner of utilizing hemispheres with incandescent gas-lights is to use the lower half of a sphere supported on a ring, with three chains radiating from a rosette at the ceiling to the globe-supporting-ring. Place a small sized inverted incandescent gas-lamp in the hemisphere, attached to a pipe-drop from the ceiling. The lamp will be invisible from below if clear glass is not used, and the effect will be found most attractive. In all cases an appropriate selection of glassware should be made."

Interior Illumination, by R. M. Searle. —*Gas Logic*, July, 1906.

A short article from a practical man, and full of good "gas logic." He says:

"Often do we see the users of illuminants start out with clean appliances, and as they become clouded with dirt they have to double the unit of light in use and then condemn the gas company. If ordinary clear gas obstructs ten per cent. of light, and opal globes sixty to seventy per cent., imagine the loss to the consumer when chimneys or bulbs build up on their surfaces successive laminations of opalescence! This loss of light due to soiling of globes is very much more serious where ground glass globes or opal globes are used than with clear glass, for the deposit is so gradual and near the color of the globes themselves that it takes months before they are so soiled as to be easily detected. The use of globes with bottom openings of small diameter causes draughts in the globe and open flames flicker badly, causing eye weariness.

"There is great necessity for displaying more wisdom in distribution of light in homes of people of moderate incomes. Why not place hall lights where they serve to illuminate the hall and at the same time throw rays into parlor or living room; why not place the kitchen light so most of it is thrown upon the sink, table and range?

"Imitation candle-burners with small, inefficient tips are often found. It is my practice to substitute the best type of tip obtainable, and arrange them so their edge is in line with the center fixture.

"Encouraging the use of portable reading lamps can be done regardless of decoration. Where connections are not handy, more side outlets should be put in. It is well to increase the number of side outlets on all new work. Persons in a household often prefer different rooms to read in, and if side lights are available they can be equipped with a suitable light to read by."

FOREIGN ITEMS

PRINCIPLES APPLIED IN THE CONSTRUCTION AND USE OF THE ULBRICHT PHOTOMETER

By Dr. M. Corsepius.

(From the *Electrotechnische Zeitschift,* May 17, 1906.)

The advantages of the Ulbricht photometer are most evident when the diameter of the globe is made large. I kept this in mind when I supervised the construction of a photometer in 1904, and I shall state here its advantages and the results obtained.

1. Construction. The diameter within its two meters; it was finished in plaster. The globe is divided vertically in two equal parts; one of these parts is fastened to the floor, the other is movable. Two small frames, made of sheet-iron and 31 cm. hign, carry the plaster parts. One of them, Figs. 1, 2 and 3, to the right, has legs that rest on the floor, the frame on the left is on wheels that run on tracks. Each half of the globe consists of an iron skeleton and its coating. The frame consists of a ring running meridianally, with cross connections, covered with wire-work. It is coated with hair plaster, and upon this is a coating of plaster of Paris. The first gives great solidity and durability, while by means of the latter a smooth outer surface is obtained, which is formed with a mould to obtain the true spherical shape.

The movable half of the globe has two handles by which it may be easily be rolled aside. In the stationary part of the globe there is at the top a metal ring, which, as the wall of the globe is 4.6 cm. thick and as the ring in the present case is 20 cm. in diameter by 11 cm. high, it extends somewhat into the space within. The window M, at the right, Figs. 1, 2 and 3, has a diameter of 20 cm., the screen S, placed on the zero point of the photometer scale, has an opening of 16 cm., but may be made smaller by means of adapters. The height of the center of the globe above the floor is 135 cm. The frames measure 140 x 100 cm. The screen B is suspended from a wire attached to the globe.

Besides the reasons given in this paper ("Etz," 1905, page 512) in favor of the use of large dimensions, I should like to add still the one, that the work with and inside the globe photometer, the suspension and the arranging of the lamps, the examination of the shadow formations affected by the screen is much simplified if considerable space is available. At the same time it is to be emphasized that the vertical division of the globe is much better than a horizontal one would be.

2. Testing. The photometer must be examined, approved, and sealed by the government for the regular measurements. As standard light-sources two incandescent lamps are first used, the spherical intensity of which has been determined by the Reichsanstalt (Government Testing Laboratory). However, before the sealing is to take place, it must be ascertained whether the distribution of the light has any influence on the readings.

Ulbricht has given a simple process for

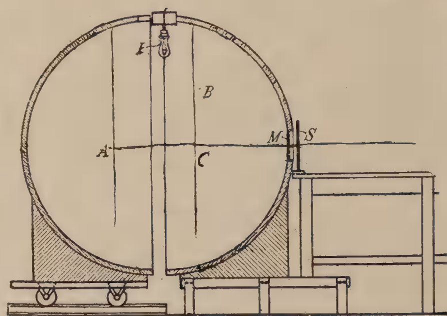


FIG. 1.

this purpose ("Etz," 1900, page 595). This method was carried out by the use of a compensating screen chosen on Ulbricht's suggestion. It may be composed of several opalescent or opal glass plates, and its action can also be regulated inasmuch as it can be brought near, or removed from, the source of the light. When Ulbricht's rules for testing were exactly followed the results were fully satisfactory, when the position and the composition of this screen were properly regulated. Then the experiment was extended so that the axis about which the incandescent lamp, screened on one side, turned was horizontal instead of vertical, and in line with the photometer scale. The light was thus directed, because of the four positions of the lamp 90° apart, first upward, then downward, next towards the person in front of the globe, and lastly away from him. In this connection it gave large errors in the readings which had to be accounted for.

For this reason an opaque shade was substituted for the compensating screen, the lamp was brought nearer the center of the globe and away from its walls; incandescent lamps were used, some of which were obscured on one side, some by a mirror coating, and some by a white coating, but finally, and what is really the most important, the shadow formations at the window were most carefully examined. It was now found that there were no differences in the readings, if the shape of the shade

and its position were so adjusted that, with a point source of light (arc lamp) not only the window itself was shaded, but also a comparatively broad band around it. When incandescent lamps are used, especially those with a wide illuminating area—as those with a mirror coating—the outer part of shade is gradually darkened, as it consists of many parts of shadows that overlap each other irregularly. The lower position of the source of light and the arrangement of the shade were retained in all the following measurements, and the shadow formations carefully observed,

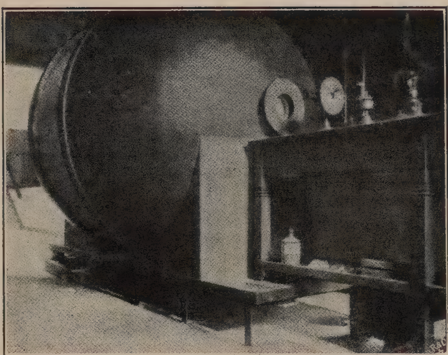


FIG. 2.

which was comparatively easy on account of the vertical division of the globe.

The final figures are: Distance of source of light L from the upper surface of the globe, 28.5 cm.; distance from the center of the shade, about 34 cm. The shade is placed obliquely and is oval shaped.

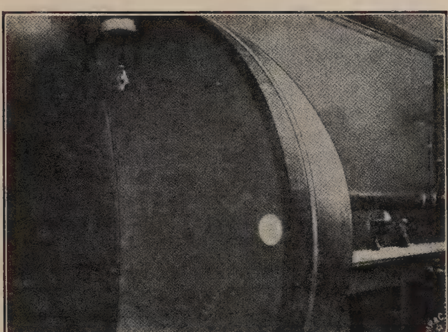


FIG. 3.

The intensity on the inner surface of the globe was examined next. Sensitized paper was placed in different places inside of the globe, and then, while either the arc or incandescent lamp was in its regular position, it was exposed. It must not be expected that all papers will be affected alike, as the rule, which it is important to observe, is as follows: The surface of the globe receives in all places the intensity H by diffuse reflexion; but it also receives the direct light of the lamp Hd that differs in all places; hence the total effect is H + Hd. Hd depends on the light distribution given by the lamp and on its distance from the parts of the surface of the globe. Therefore all papers would receive the same amount of light only in case each of them were used with its own shade. The observations with a Nernst lamp, however, gave no considerable differences, only the paper on the very top near the lamp had become darker on account of the direct rays.

3. Use. The apparatus was legally tested without any objections by means of the above mentioned standard lamps, but it was understood that carbon filament, osmium, or tantalum lamps, i. e., those with vacuum bulbs only, should be measured. It must be noted that one was a 32 c. p. standard lamp for 110 v. with spiral shaped filament, and the other one had a U shaped filament and 16 c. p. at 50 v. Hence the intensity and the distribution is different in each case. The legal test was made immediately after the arrival of the lamps, and the intensity of other incandescent lamps, particularly of one of 32 c. p. that had been burning for 100 hours, was ascertained according to it; these lamps, or those that were again tested after them, were to serve as secondary standards, in order that the main standards might be spared a frequent use, so that they might not undergo considerable changes. The photometer screen is constructed as directed by Lumner-Brodhun, and carries a telescope that is placed vertically to the photometer scale. As shown in Fig. 5 it has a shade to protect the window from the rays of the secondary standards. As a secondary standard a 16 c. p. lamp was generally used, with one of 32 c. p. in circuit in front of it. Not only were these same lamps always used, but the direction in which their light was allowed to radiate was also exactly noted and remained fixed. Lately an osmium lamp of 4 c. p. at 5 v. has been substituted for the 16 c. p. lamp.

The whole length of the photometer scale is 3 m., but only 2 m. of it were used. The measurements have been chosen such that the movable photometer serum is to be placed generally not far from the center of the portion of the scale used. The coloring of the light that radiates from the 16 c. p. standard lamp is reddish. This fact was no obstacle at all, not even in the case of arc lamp mesurements, hence gives no occasion for objections, because the human eye with its remarkable sensitiveness to light, always serves as the medium by means of which the adjustments are made. Even if there is, because of different colorings, no balance in any position,

the right point may be easily found by the inversion of the two beams of light on the photometer screen. When an osmium lamp is used as a standard the differences in the color are considerably smaller.

4. IRREGULARITIES. If not only incandescent lamps with vacuum bulbs, but also Nernst and arc lamps are to be measured, we have then a case as described by Ulbricht in "Etz," 1905, page 513, where the surface of the body within the globe differs each time.

I met these complications and prevented the test values from differing by using the lamps with the ring (or cylinder) above mentioned. It represents a body that always remains the same, and though its surface is not large it is sufficient to compensate for the casings of arc lamps. Hence differences remain only in so far as the surface of this lamp holder differs from that of the guide-rods, carbons, and reflectors of arc lamps, and from the surface of the casings of Nernst lamps, as regards size and reflective power.

Ulbricht's observations ("Etz," 1905, page 513, show a way to find the discrepancies in the measurements from the true value, when the same constant value is used for the calculations. The process of testing each lamp is not difficult, but it reduces the greatest advantage of the photometer, that is, obtaining results quickly. The determination of the constant value is done much better by adjustments and observations under the same conditions, than to ascertain the small percentage differences of the same in different lamps; hence the first case is more accurate.

The proportion of the illumination without the introduction of foreign bodies to that with foreign bodies is, according to Ulbricht,

$$(1) \quad \frac{H_0}{H} = 1 + \frac{O \cdot a_1}{4 r^2 \pi a} \frac{(1 - a)}{} : 1.$$

The constant value changes according to the dimensions of the same, as for instance o (= surface) = 1,265, by 54.8 per cent. This is a considerable amount. But in my photometer the diameter of the globe is not 50 but 200 cm., or four times as large as in the above observations. Besides, the surface of an arc lamp of Siemens and Halske, for instance, that is similar to the one investigated, extends within 670 ccm., including guide-rods, carbons, economizer, and reflector. The percentage is then, if we assume the same conditions for absorption, to be changed in proportion to above quotation, thus:

$$(2) \quad \frac{670}{1265} \cdot \frac{25^2}{100^2} \cdot 54{,}8 = 1{,}82\%$$

This quantity is still to be increased by a certain amount that is found from the following: The inserted cylinder was, for measurements for incandescent lamps, covered with a piece of asbestos, that had a round opening of 9 cm. diameter in the center. For arc lamp measurements no such diaphragms were used. The constant value K increases therefore through the black spot in proportion:

1. For arc lamps

$$(3) \quad 1 : 1 + \frac{1 - a}{a} \cdot \frac{O}{4 r^2 \pi}$$

or, when a = 0.16

$$(4) \quad 1 : 1 + \frac{0{,}84}{0{,}16} \cdot \frac{314}{4 \cdot 100^2 . \pi} = 1 : 1{,}0131$$

or enlargement by 1.3 per cent.

2. For incandescent lamps, including Nernst lamps

$$(5) \quad 1 : 1 + \frac{0{,}84}{0{,}16} \cdot \frac{63{,}7}{4 \cdot 100^2 \pi} = 1 : 1{,}00267$$

or increase by 0.27 per cent.

The difference in both cases is therefore 1 per cent.

According to this the light intensity Js calculated from constants found for incandescent lamps in the above case is to be increased on the whole by 1.82 + 1 = 2.8 per cent.

An arc lamp from Koerting and Matthiesen gave o = 531 cm.; compared with Ulbricht's measurements of an arc lamp without reflecting plate with o = 750 and 41.2 per cent. increase there is in the same way, as just deduced, an increase of 2.8 per cent. on the whole.

In the case of an alternating current arc lamp from Siemens and Halske o was = 613, the corrections therefore, 2.7 per cent.

Given for the Nernst lamps for the part extending within of polished brass and white porcelain o = 331 ccm., a_1 = 0.4, the increase is then 1.1 per cent.

To verify the values found by calculations the following test was made: An incandescent lamp with shade consisting of a cap made of drawing paper, as Ulbricht directed in "Etz," 1905, page 514, was placed in the lower part of the globe. Then reading was made with the photometer, first when, besides the above lamp, there was on the upper part of the globe an unconnected incandescent lamp; and second, when on top in the diaphragm there was the continuous current lamp of Siemens and Halske. The readings in the first case were Js = 23.6, in the second case Js = 22.7. The proportion of the two is

$$\frac{23.6}{22.7} = 1.04,$$

hence the difference, 4 per cent. The calculations gave 2.8 per cent., the agreement, therefore, is sufficient.

The last considerations show us that, in the present photometer, the influence from dissimilar seize and form of the parts that extend within, is small. Besides, correc-

tions according to the above amounts could be made on the observed values, without the possibility of large errors, even when, as in the Nernst lamp, only a_1 is assumed. In this case it is only 1 per cent. that may be neglected also. These corrections are to be made use of by the values given below.

5. The Light Distribution. The value which it is important to know in regard to any source of light is undoubtedly in the first place the spherical candle-power. It gives the correct measure for economy, because by means of it we know what light we receive for the money; the light intensity in one direction is almost without value for judging this, and the hemispheric intensity also gives very objectionable measurements. It would, therefore, in my opinion, be regrettable, if for arc lamps in the future the spherical intensity were not accepted as a standard, no matter how tempting the higher figures may be to many.

It is simple to put a light to good use in one or in all directions, but it is naturally important to know whether we need for the required effect more or less special apparatus to aid us. A knowledge of the position of the maximum intensity and of the manner of the light distribution is therefore desirable.

The described photometer may serve in the following way to answer these questions in a simple manner. I bring the source of light in the center of the globe and move the two halves towards each other so that a space, only a few mm. wide, remains. Through this the light radiates in. The globe is graded on the outside, and there its natural distributor, a rubber band, serves to cover the gap. Underneath the same we place in several places about 10° apart, a piece of sensitized paper and then connect the lamp. In the case of arc lamps the paper has been sufficiently exposed after about an hour, when it is removed and fixed. An illumination by diffuse light is not to be feared on account of the thickness of the wall of the globe, but we can do away with it entirely if we suspend a blackened tin, A, behind the source of light. The possible objection that probably the ultra violet light might have a different distribution than the visible light, may be met by having it absorbed by glass plates, C, etc., placed in front of it. Experiments that have been made in this respect, however, did not give any notable difference.

Of special advantage in this process, aside from its simplicity, is the fact that the photograms are the results of long exposure, and thus give a mean of the light distribution, insead of depending on an accidental momentary adjustment of the arc. By repeating the photographing the differences are increased.

6. Results of the Observation. A few values in numbers are given that show the results obtained with the photometer, the corrections to be made, and the differences of the lamps, and that serve at the same time as a contribution to the question of economy of the latest lamp types (see Table I.). The results show that continuous current arc lamps are much superior to alternating current arc lamps; that the alternating current arc lamp that is normally arranged for 10 amperes gives, as soon as it is overtaxed, a much better economy. Though it might have been noted by many that alternating current arc lamps become rather useful with very great current strength (from 25-35 amp.) and that better light is obtained with the thinner than with the normal carbons, still the fact that in general the latest incandescent lamps are preferable to the alternating arc lamp, is worth noting. Ordinary incandescent lamps appear each to have a different effect, rather unfavorable, as all the lamps had burnt only a short time, 100 hours at the most, under a normal tension. All later kinds of incandescent lamps are much more profitable. In the case of tantalum lamps, the increased economy may be noticed after a few hours. Attention is called to the Nernst lamps, that gave good results under the less favorable tension of only 110 v., though some of them had been burning for a long time. Comparing a mixed illumination of old and new Nernst lamps with osmium and tantalum lamps, it is, of course, necessary to use somewhat higher figures for watts consumed for the last mentioned two sorts than the value indicated in the table for the new lamps. The difference in price of the substituted lamps is also to be considered, especially if the current, as in case of isolated plants, is cheap.

SYNOPSIS.

1. A large diameter and a vertical division of the globe photometer are much more advantageous than all other constructions.

2. The photometer may be conveniently used to readily ascertain the light distribution according to the procedure as I have given it.

3. It is important to measure the shadow formations accurately.

4. In the case of large measurements it is safe to assume for all kinds of lamps the same constant value, and, if necessary, make small corrections on the result.

5. The observations made with the described photometer give already some explanation of the peculiarities of the different sorts of lamps.

6. The globe photometer is built on an exact basis, and if used as directed, it is an instrument that is very suitable for the practical application, and requires but little attention from the observer.

SOME CAUSES OF ERROR IN PHOTOMETRY

By Lancelot W. Wild.

Electrician (London), July 20, 1906.

Few photometrists properly appreciate the importance in photometry of the elimination of angularity errors. Such errors are in many forms of photometer very much greater than is generally supposed, and are not by any means entirely overcome by making a double balance and the employment of a comparison lamp.

In general the art of photometry may be said to consist in judging the illumination of two contiguous surfaces, each being lighted from a separate source. A perfect screen may be defined as one which appears equally illuminated at no matter what angle it is viewed, the illumination being also exactly proportional to the cosine of the angle from the perpendicular at which the light rays strike its surface. It is hardly necessary, however, to say that such perfect screens do not exist outside the domain of mathematics.

Variation of Illumination with Angle of View.—That the apparent illumination of a screen varies slightly with the angle of view is no doubt well known. That this variation depends greatly upon the nature of the surface is also well known. As to the effect upon photometer screens, however, there is little information available. The following test, carried out on a Bunsen disc, will, however, serve to illustrate the magnitude of the errors that are likely to occur.

A Bunsen disc was set up between two incandescent lamps. The disc was then viewed at various angles and one of the lights shifted till balance of illumination was obtained. The apparent candle-power of the moving lamp at the various angles of view was found to be as follows:

Angle of View.	Candle-power.
20 degrees from perpendicular...	9.0
30 " " " ...	9.4
40 " " " ...	9.7
50 " " " ...	9.9
60 " " " ...	10.0
70 " " " ...	9.5

It would appear from these tests that, in the case of this particular screen the best angle of view is at about 50 to 60 deg. For every accurate work it is advisable to fix the angle of view fairly accurately. This can be done in two ways, first by using a couple of plumb lines in the center of the field of view, or better still, by viewing the disc through a longish tube.

Errors Due to Side-play of Carriage.—There are several forms of photometer screen in general use in which the two surfaces to be illuminated are inclined in opposite directions, the light rays from the lamps falling upon them at a considerable angle from the perpendicular. The following are well-known examples: The Ritchie wedge, the Trotter screen, the Whitman flicker screen, and the Simmance-Abady flicker photometer. In the first three of these the rays commonly strike the surfaces at an angle of 60 deg. from the perpendicu-

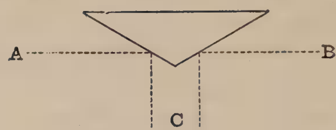


Fig. 1.

lar, the surfaces being inclined horizontally. In the Simmance-Abady photometer the light strikes at an angle of 50 or 55 deg. from the perpendicular, and the surfaces are inclined vertically.

Fig. 1 shows diagrammatically a Ritchie wedge. The lights are at A and B, and the eye of the observer at C. The wedge is generally mounted upon a carriage which can be moved along some form of bar or rails. As the motion of the carriage must be easy, it is impossible entirely to prevent horizontal side-play occurring between the carriage and bar. Now, suppose that the carriage is displaced slightly and is turned through a horizontal angle of, say, 1 deg. The illumination of one surface will be increased and the other reduced. The amount of change taking place on each surface will be proportional to the difference between the cosines of the angles at which the rays strike the surfaces. If, under normal conditions, the rays strike the surfaces at 60 deg. from the perpendicular, then a deflection of the carriage of 1 deg. will increase the illumination of one surface by 3 per cent. and reduce that of the other by 3 per cent., making a total error of 6 per cent. There are very few photometers in use in which the carriage cannot be deflected through this small angle of 1 deg., so the errors involved are perhaps more often greater than less than 6 per cent.

In the case of the Simmance-Abady photometer, the two surfaces being inclined vertically instead of horizontally, there is no error due to side-play between carriage and bar. There will be, however, a considerable error if the wheels of the carriage are not quite true or if the bar is not dead straight. In the tilting form of Simmance-Abady photometer there is a considerable error brought in if the photometer is tilted slightly by inadvertence whilst re-winding the clockwork motor. The tilting scale cannot be easily read closer than to 1 deg., and this displacement will produce an error in the measurement of 5 per cent. This would be 6 per cent. if the rays were to strike the surfaces at 60 deg. from the perpendicular, as in other forms of photo-

meter, instead of striking at about 50 or 55 deg.

When the two surfaces of the screen are parallel and perpendicular to the light rays, as in the Bunsen, Joly and Lummer-Brodhun photometers, side-play between the carriage and bar involves no measurable error, as the two surfaces to be viewed are at all times parallel, and any tilting of the carriage reduces the illumination of both surfaces to the same degree.

Errors Due to Incorrect Alignment of Lights.—Again taking the Ritchie wedge as an example, supposing that one of the lights is displaced horizontally and at right angles to the photometric axis by ½ in., the distance from light to screen being, say, 30 in. This will cause the light rays to impinge upon the screen at an angle of 59 or 61 deg. instead of 60 deg., and will produce an error of 3 per cent. in the measurement of candle-power. If both lights are out of alignment by this amount, the total error involved may amount to 6 per cent. With a Simmance-Abady photometer horizontal displacement is of no moment, but vertical displacement is of great consequence. A displacement vertically of ½ in. in 30 in. in the case of the Simmance-Abady flicker photometer will produce an error of about 2½ per cent., and if both lights are out of alignment as much as 5 per cent.

A displacement of ½ in. either vertically or horizontally is by no means abnormal, when ordinary incandescent lamps with irregular filaments are dealt with. Even if arrangements are made for moving the lamps in all directions with a view to bringing them into exact alignment it is very difficult to judge sufficiently exactly the true photometric center of the filament.

With a photometer screen so arranged that the rays shall fall perpendicularly upon the surfaces to be viewed, the error due to a want of alignment is quite negligible, a displacement of one light by ½ in. in 30 in. producing an error of only 0.02 per cent., this being the difference between cosine 0° and cosine 1°.

There are to the writer's knowledge but two forms of flicker photometer on the market—namely, the Simmance-Abady photometer made by Messrs. Alexander Wright & Co., and the Whitman flicker photometer made by Messrs. Everett & Edgcumbe. On account of their angularity errors neither of these photometers are sufficiently accurate for laboratory work of the highest class, and the writer would very much prefer to work with a simple Bunsen disc, even when the color difference between the two lights is as great as between a Welsbach burner and a flame arc lamp. As, however, the use of some form of flicker photometer is advisable where the color difference is appreciable, the writer some time ago started to investigate the question of angularity errors, and arrived at the following general principles as being desirable in any form of photometry:

General Principles for the Avoidance of Angularity Error.—The two surfaces to be viewed must be absolutely parallel, so that side play between carriage and bar may affect the illumination of both surfaces in the same direction and to the same degree.

Both surfaces must be normally perpendicular to the light rays falling upon them, so that should either light be out of true alignment the effect upon the illumination shall be negligible.

The surfaces must be viewed through a tube, so that the angle of view cannot become changed to any appreciable extent. A telescope answers the purpose very well.

Bearing these general principles in mind,

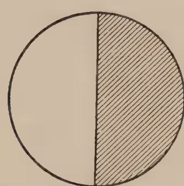


Fig. 2.

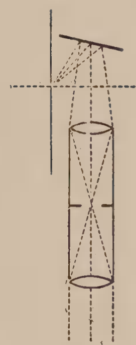


Fig. 3

the writer found that it was not a very difficult matter to produce a flicker photometer that was quite free from angularity errors.

Description of Flicker Photometer free from Angular Errors.—The form of flicker photometer which the writer can confidently recommend for work of the very highest class consists of a special form of Bunsen disc revolved by an electric motor and viewed by the agency of a mirror and telescope. Fig. 2 shows the disc, which is cut out of ordinary white blotting paper and has about half of its surface treated with white paraffin wax, so that half the disc is opaque and reflecting and the other half translucent and diffusing. The disc is revolved on its center by means of a small 2 volt motor. A small portion of the upper part of the disc is viewed through a mirror and telescope. The arrangement of mirror and telescope is shown in Fig. 3. The object of using a telescope instead of a simple lens is that if no diaphragm is used the eye finds it very difficult to keep in focus on the disc, which, when revolving, shows no detail. As arranged, an image of a portion of the revolving disc is formed, in the air so to speak, inside the diaphragm.

The eye-space is adjusted till the diaphragm appears in focus and thus the eye is automatically focused upon the revolving disc. Keeping the disc in absolute focus increases the sensitiveness of the photometer and at the same time very greatly reduces the fatigue to the eye.

A couple of these photometers have been in general use at the Westminster Electrical Testing Laboratory for the past three months and have given entire satisfaction. Their sensitiveness on lights of the same color is at least as good and probably better than that of any other of the usual forms of photometer. On lights differing as to color the sensitiveness of course falls off slightly on account of the high speed of rotation required to eliminate color flicker. The photometers have been tried tilted as much as 10 per cent. out of truth and with one or both lights as much as 6 in. out of alignment, and, within the limits of experimental error (about ½ per cent.), no angularity error has been found.

The writer will be pleased to show these photometers to anyone interested in accurate photometry.

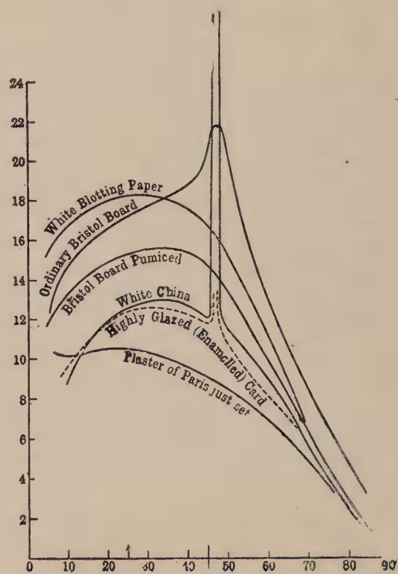
SOME CAUSES OF ERROR IN PHOTOMETRY

To the Editor of *The Electrician.*

Sir:—Mr. L. W. Wild's article on p. 529 usefully calls attention to certain errors which may arise through neglect of angular adjustments, but he illustrates his subject by reference to ill-designed and ill-made apparatus, and he alludes to the "Trotter screen." I would not have complained had he not used this again, in his letter to you on p. 589, as a shocking example. If Mr. Wild has found an instrument with a side shake amounting to (deg., and with screens on which the light is incident at an angle of 60 deg., I must beg him not to call it a "Trotter screen." I have designed several kinds of photometers for different purposes, and the particular pattern which Mr. Wild probably had in his mind was briefly described in the *Proceedings* of the Physical Society of London, Vol. XII., December, 1893, pp. 345-360, and in *Phil. Mag.*, July, 1893. That paper described two kinds of screens, one with two lozenge-shaped holes, one over the other, and one with a long grid, specially intended for work with rapidly fluctuating lights." The screens were held in a frame capable of rotation round a vertical axis through a small angle, for the purpose of producing small and rapid variations." The simple form was more fully described in the *Journal* Inst. Elec. Eng., Vol. XXXII., pp. 188-189. There is so little new in the principle of this that I have never claimed it as the "Trotter photometer."

In a paper read on the same day (June 9, 1893), Prof. S. P. Thompson referred to the use of two opaque screens by Sir John Conroy in 1883. Those screens were inclined at about 60 deg. to one another—that is, an angle of incidence of 30 deg. "He found, as I did," wrote Prof. S. P. Thompson, "that 90 deg. is too large a dihedral angle for exact work." The Thompson-Starling photometer described in that paper has two surfaces meeting at an angle of about 70 deg.

I made some experiments on this point in 1895, but the records have been mislaid, and I have never had an opportunity



to go on with the work. On October 31, 1895, I wrote to Messrs. Nalder Bros., who were making what they called the Trotter bar photometer (as distinguished from the illumination photometer): "I enclose a few curves forming part of a research on which I have done but little as yet. The angles refer to the position of the back screen of a photometer, the front one remaining fixed. The vertical scale is read directly off the photometer bar. The two lights were equal, and when the photometer reads 10, the angles being the same, the balance is the same, and the reflecting powers of the screens are the same. If the screens are not made of the same material, *or* if the angles are not the same, and the photometer records, say, 5, the brilliance of one screen is therefore half the brilliance of the other. I only trouble you with this in order to show that 35 deg. (or as marked here 25 deg.) is on the flat of most of the curves. This means that a trifling error in the angles of the screens will not affect

the truth of the photometer, and, what is more important, a deviation of the position of the light from the true axis does not matter."

I cannot remember why I called attention to 25 deg., but the general results show that if anyone is so foolish as to use an angle of incidence of 60 deg. he would be liable to such an error as Mr. Wild discusses, and that with an angle between 30 deg. and 40 deg. such an error may be eliminated. The curves are traced from the rather blotted copy in my letter book, and I regret that I cannot indicate the observed points on them.

Yours, etc.,
A. P. Trotter.

Whitehall, S. W., July 31.

To the Editor of *The Electrician*.

Sir:—I have read Mr. Wild's letter of the 27th ult. in reply to mine in the same issue. I cannot, however, agree with him that it is *impossible* to avoid errors of the magnitude of 3 per cent. due to want of alignment of lights. In the first place, if he will refer again to my letter, he will observe that the one case mentioned by me—viz., that of the street-lighting photometer—will not be affected in this manner, since the distance between the lamp tested and the photometer head is very much greater; and in the other case, of the central-station photometer (and, by the way, the photometer head under discussion was the "Flicker" and not the "Trotter"), the error due to the special case of accidental bending of filament can, with similar lamps —*i. e.,* lamps of the same make and shape of filament, be compensated for very largely by viewing in the vertical plane. This exceptional case, I think, is a little far-fetched, although in the exact circumstances that he mentions it is sound enough, since in the case of important work, where such errors as 3 per cent. are of moment, such defective lamps would be discarded. The method of viewing in the vertical plane is, of course, subject to alignment errors of the same order where the lamps are of different heights; but, in any case, it is fair to assume that in such work some care is take nto ensure that the C.G. of the filament is in the correct position. When it comes to heterochromatic photometry, the color errors, due to the use of the "Trotter" screen, will quite swamp the alignment errors, and therefore the latter are of small importance.

At the same time, I should like again to say that articles discussing the possibilities of such errors are extremely valuable and are much appreciated by manufacturers.

Yours, etc.,
G. J. Lemmens.

Westminster, S. W., August 1.

STANDARDIZATION OF ARC LAMPS

Report of the Photometric Commission of the Association of Electrical Manufacturers and the Society of German Electrical Engineers.

The Committee on Photometry of the Association of Electrical Manufacturers, and of the Society of German Electrical Engineers, have adopted the following "Standards for Arc Lamps" and "Rules for the Photometry of Arc Lamps," which are to be authorized at the annual convention in Stuttgart. The commissioners also decided to give the necessary explanations and particulars. The members of the committee are as follows: Messrs. Blutgen, Kallman, Marxen, Norden, Overman, Passavant, Remané, Teichmuller, Thomas, Ulbricht, Uppenborn, Utzinger, Wedding, Wissman, and Zeidler.

Standards for Arc Lamps.

The efficiency of an arc lamp is to be calculated with regard to the most important area of distribution, namely, the direct illumination of the space that lies below an imaginary horizontal plane drawn through the source of the light.[1] For a standard, therefore, the mean lower hemispherical candle-power (abbreviated, J ⊏) measured in HK (Hefner candles), is to be used. When this intensity is given in Hefner candles the index "Ʊ" is to be added to HK thus: HK Ʊ (hemispherical Hefner candles)[2].

This statement is to apply to arc lamps as regularly used, without reflector; and where globes are used (in case of enclosed arcs, both inner and outer globes), they are to be of transparent glass of the same dimensions.

Statements of the influence of diffusing globes, reflectors, etc., are to be made with regard to the intensity as defined above.

Statements of intensities in alternating current arc lamps are, if not otherwise stated, to refer to a sine curve form of potential, and a frequency of 50 cycles.

The practical efficiency of an arc lamp in series is the total consumption of the circuit, measured where it branches from the mains, divided by the number of the lamps in the circuit. In stating this efficiency the potential of the mains is to be given.

The specific practical efficiency of an arc lamp is the efficiency thus found, divided by the light intensity Ʊ. To give this quantity the following expression should be used: "W/HK Ʊ at *n* voltage at the mains." (= Watts per hemispherical Hefner candle.)

In every case of an alternating current lamp it must be stated whether it has a rheostat or an impedance coil.

The value of "HK Ʊ/W at *n* main voltage" is the practical light efficiency.

Rules for the Photometry of Arc Lamps.

(To be tried for one year.)

Before the photometric measurements are made the arc lamps are to be provided with carbons of prescribed diameter and make, and of a length such that it will last about half the life of the lamp; and it is to be put in regular operation for an hour. Then, without disturbing it by the taking off of the globe or in any other way, the measurements are to be taken.

J $\mho$ is ascertained either by making use of the mean polar curve, or with the aid of an integrating photometer (Ulbricht Globe). The separate polar curves are to be plotted in such a manner that the values in the measuring plane are carried out simultaneously on both sides of the lamp for the same angle. The measurements in this plane must not be more than 10° apart. The measuring plane in the case where the carbons are one above the other is the plane passing through the axes of the carbons. In the case of lamps with the carbons side by side two measuring planes must be taken, one of which coincides with the plane of the carbons, the other perpendicular to it.

The Ulbricht Globe must have a diameter of at least 1.5 m.

Explanations and Particulars.

(1) There could be no doubt from the beginning that the fixing of a certain intensity of light as a standard measure for arc lamps could only serve as a rough commercial rating. The illuminating engineer who makes plans for the illumination of a street, square, or room, has to take the exact light distribution (polar curve) into account; a single maximum or average value is of no use to him. It must be repeated that there is no direct way, either in theory or in practice, to find the average illumination on a street surface or in a room from the average intensity of a lamp, but this can be obtained only by finding the average value from the separate values that have been found from the polar curve of the lamp for the illumination in different places. For the comparison of different types of arc lamps, or of different sources of light, as arc light with gaslight, etc., the average value of light intensities is also entirely unsuitable; at least such general comparison, without the consideration of its purpose, it without practical value, as the true value of a source of light may be very different with different kinds of illuminations; and it often happens that a source of light, A, may be better in one case than another one, B, and yet for another illuminating purpose it might not be as good. Hence the comparisons of different arc lamps and other light sources can only be made in case of concrete examples of illumination, and always have to fall back on the curves of distribution, while nothing can be done with the average values of light intensities.

It is best in the very beginning to abandon the idea that the light intensity adjusted to a standard can be available for all cases for judging the illuminating efficiency of a lamp, and to be satisfied if the standard is sufficient to roughly characterize the lamp in the majority of actual cases.

Considering the purpose of all standards, it is also plain that this case reduces itself to a practical valuation of arc lamps, and therefore the applications from which the standard is made are to come from practical illumination.

Now, it is true that, in most problems of practical illumination only that flux of light is useful which falls in the lower half of a sphere described about the source of the light. In this class belong all cases of direct ground illumination, such as street, track, square, and similar illuminations; also in illuminations of large halls where there is very little reflection from above; and the illumination of closed rooms, as far as it is effected by the direct light of arc lamps, depends mostly upon the quantity of the light radiated into the lower hemisphere, the light sent into the upper hemisphere that is partly used through reflection, being of little importance, as it can add but little to the intensity.

The same result is obtained on considering the conditions of the radiation of the light of arc lamps themselves. All known types of lamps radiate their light almost entirely in the lower hemisphere, while the part sent in the upper hemisphere is so small that it does not enter into the account for practical illumination. Alternating current arc lamps, that theoretically throw as much light up as down, are in practice used only with reflectors that reflect the upward rays so well that but little of the curve of distribution in such cases is above the horizontal line. Enclosed arc lamps are used in practice with two, or at least with one frosted globe, that throw the rays into the lower hemisphere.

The only case in which the above is not true is in indirect illumination.

The question whether it is possible at all to apply the standard to arc lamps for indirect illumination has been taken into consideration, and finally answered in the negaitve. If it is difficult to find a standard value for the direct light of the arc lamp that is applicable to the illumination, it is quite impossible in the case of indirect illumination. The color and form of the ceilings and walls, the material and shape of the reflectors of such indirect lamps, through which the light sometimes passes, are all of enormous influence on the efficiency of an arc lamp for indirect illumination, and in most cases do not permit of exact measurements, and certainly not of standardizing. These great difficulties, to-

gether with the consideration that indirect illumination in practice, to which the standard is to be applied, is little used when compared with direct illumination, have led to the conclusion that, for the practical valuation of the light-efficiency, only direct illumination is to be considered.

In accordance with the above the members of the commission have unanimously voted to adopt the mean lower hemispherical intensity as a fundamental standard.

It was also suggested to adopt as a standard, besides the above, the mean spherical intensity. This was not accepted because of the misunderstanding and uncertainty in giving light guarantees, which are to be avoided in future by giving absolutely specified values.

If the intensity of lamps were given in two different standard values, there would also be two different values for the specific efficiency and for the total flux of the lamp; in short, there would be no end of confusion. Besides, the flux of light upward by the ordinary arc lamps is so small that practically there is no difference between the spherical and hemispherical intensity; so that there would be nothing gained by a further rating of the lamp.

For this reason the commission has adopted the mean lower hemispherical intensity only.

(2) The sign "◡" (representing the lower half of a sphere) is needed for statements that refer to the standard in order to have them marked for use in literature. HK does not mean a special sort of Hefner candle, but a value that is obtained by a certain process laid down for measuring it. The association cannot make any rules as to the making of statements with reference to the standard for business or literature, because such agreement depends, after all, on the good will of the author or manufacturer. The index "◡" gives a precise meaning, and though nobody is forced to use it, the idea of a standard is not given if it is not added.

(3) Considering that above all the standard is meant for use, the first thing to do would be to photometer the lamps under exactly the conditions in which they are to operate. That would mean wherever the lamps in operation have reflectors, or frosted globes, that they are to be measured under those conditions.

But there is one difficulty where frosted globes are used; their absorption varies within large limits, and hardly two globes exist that have the same absorption and distribution. Hence a measurement once taken of an arc lamp with frosted globe is no longer of any use if the original globe either no longer exists or has become slightly defective through use, and it is thus actually impossible to make definite subsequent statements about the light-power of such a lamp.

The only kind of globe that does not practically change its absorptive power is the transparent globe, which is therefore especially suitable for standard measurements. Of course, the value for the latter is higher than that for the first, but it is much preferable to measuring the bare arc, because all conditions of the arc (its length, air circulation, etc.) remain the same as when in practical use.

The absorption of frosted glass globes may be given by stating approximately their average value.

Reflectors are not to be used because of the easier manipulation in photometering; the effect of reflectors upon the intensity is, as we know, very small.

(4) The practical efficiency of an arc lamp is to include its consumption together with that of the resistance-coil, the choke-coil, or the transformer, as the case may be; for only when they are considered has the statement of efficiency a practical value for comparisons as to economy. The simplest way to find it is the one given above, namely, the measuring of the total consumption at the connections with the mains, and dividing this value by the number of lamps. Giving the voltage of the mains is needed because the efficiency thus measured gives different results, according as, for inst., two lamps are connected with 110 or 120 volt mains, and hence to define the conditions for which the statement is made the voltage of the mains is needed. However, the number of lamps burning in series does not have to be mentioned, as besides the points already given there are no others that aid in judging the efficiency of the lamp.

(5) It would be wrong to attribute generally the efficiency of alternating current arc lamps to a resistance without induction, because this would mean a disadvantage to these lamps, wherever they burn with choke-coils. Nor must we refer the efficiency only to resistance with induction, because, especially in Germany, the manufacturers are liable to prohibit the installation of such coils. Hence it is necessary to consider the particular case in hand; but in order to avoid lack of precision and false conclusions, to give each time distinctly the kind of resistance used.

(6) The rules for the photometry of arc lamps have been worked out according to the present state of technical photometry. Considering the fact that much work is being done in this field at present, it is recommended that these rules be revised at the end of one year.

DEVELOPMENTS IN THE BASTIAN MERCURY VAPOR LAMP

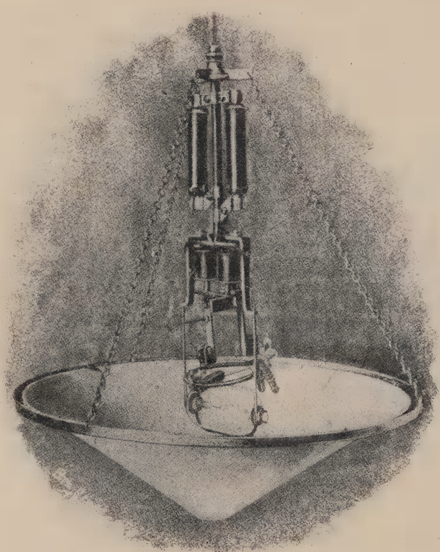
The Electrical Review, July 13, 1906.

The Bastian type of lamp is of peculiar interest, owing to its English origin and to the very practical designs adopted by the

makers. So recently as January, 1903, the first patent was taken out for this lamp, and about the middle of the following year the first few lamps, arranged to burn four in series across 200 volts, were sold.

By the end of the year 1904, it was found possible to construct the lamps to burn singly on any voltage up to 250 volts, and since that development, little, if any, change has been effected in the method of manufacturing the burner, except as regards improved methods of annealing, etc.

The burners are made of hard Jena combustion tubing, and as this glass has a much lower coefficient of expansion than platinum, considerable difficulties have had



BASTIAN MERCURY VAPOR LAMP.

to be overcome in effecting a thoroughly reliable sealing-in of the platinum leading-in wires, but that these difficulties have been overcome is evidenced by the fact that many burners have lasted over 5,000 hours in actual use, and one, specially tested, had a life of over 10,600 hours under conditions of practical use. During this long period very little discoloration of the glass took place, except for a short length of about ½ in. near the negative electrode, and it is claimed that the efficiency of the lamp was not reduced more than 5 per cent. thereby.

It is almost superfluous to remind our readers that this type of lamp is highly efficient, being some ten times better than the ordinary incandescent lamp; and to those who object to the color of the mercury vapor, pure and simple, it will be interesting to know that the firm is busily experimenting with a view to coloring the arc stream by the addition of other metals to the mercury.

Our illustration shows one of the latest patterns of lamp, used by ourselves for office illumination; as will be seen, it is combined with an incandescent lamp, thus obviating the color difficulty for internal work. The lamp is not essentially different in construction from earlier ones described in our pages, but it is improved in several minor points.

Sole licenses to work the patents in France and Spain have been acquired by the Compagnie Generale d'Electricité, of Paris, and in Switzerland the sole license is held by the Schweiz Gluhlampen Fabrik, of Zug, whilst the Cooper Hewitt Electric Co., of New York, have acquired an option to purchase all the rights in the United States and Canada.

The grant of the company's patents has been opposed in several foreign countries, but the firm has so far in all cases successfully contested such opposition, and the German patent which was opposed has just been finally sealed with the full broad claims orginally allowed by the German Patent Office.

THE PENETRATING PROPERTIES OF THE ARC LIGHT

The Electrical Review (London), August 3, 1906.

Several statements *re* light penetration have appeared recently in the "Correspondence" columns of the electrical Press, the accuracy of which I seriously question.

In the *Electrician*, of July 20th, 1906, M. Laporte writes:—"It is generally agreed that the air in the neighborhood of the earth is more transparent for yellow and red radiation than for radiations of shorter wave length."

And again, in the *Electrical Review* of July 27th, 1906, the following statement occurs in a letter from the Kitson Light Foreign Supply Co.:—"Any lighting engineer knows * * * that the blue rays which preponderate in the electric arc will not penetrate the fog for any distance, whilst the red and yellow rays do, and as the Kitson system is rich in these, it stands to reason that it should be a better illuminant during fogs than the electric arc. The same is true of the oil-wick lamp and an ordinary gas jet."

I do not question the statement that an oil-wick lamp will penetrate fog better than the light from a carbon arc, but I question the accuracy of the explanation, which is generally accepted as the true one.

I maintain that the difference in the penetrating properties of the two lights is entirely due to the difference in what is usually termed their intrinsic brilliancy, but which I prefer to term the difference in the light density of the two illuminants.

I think it will be found that if the two sources of different colored illumination have the same flux of light per square centimeter of radiating surface, then the illuminant rich in blue light will penetrate the atmosphere somewhat better than the illuminant rich in red and yellow light.

If I am not correct in stating that blue light penetrates the atmosphere better than any other color, perhaps the manager of the Kitson Light Foreign Supply Co. will kindly explain to me and others through your columns, why it is that distant objects appear blue.

C. Orme Bastian.

London, N. W., July 30th, 1906.

LIGHT—COLOR—VALUE

(*The Electrical Review*, August 3, 1906.)

There have been many discussions lately in the technical press and elsewhere on the subject of light, the relative value of gas and electricity, the proposed standardization of electric lamps, etc., and I have been much struck by the absence of any exactness or definiteness as to what light should be. In nearly all these discussions the value of light is regarded on the basis of the quantity or intensity only of the light given by each illuminant, the quality being always ignored or dealt with in quite a cursory manner. The efficiency of electric incandescent lamps, "open," "enclosed" and "flame" arc lamps, Nernst and mercury vapor lamps are all discussed in similarly unsatisfactory style.

Surely it is possible to determine what is useful light, and to obtain an authoritative dictum as to what is best suited for the human eye.

It is commonly stated that what we want it white light, and each lamp merchant claims to have produced a counterfeit of or improvement on the sun. White light is, of course, a compound, and what we want is an authoritative decision as to which primary color or combination of primary colors is required for human use. I was surprised to hear Mr. Swinburne say at the Electrical Exhibition that probably the best quality of light for home use would be obtained from numerous coal fires dotted about our rooms, but that it would be the most costly. Well, the best generally is the most costly, and the practical man was created especially for the purpose of finding the nearest approach to the desirable at a practicable price. It is no use saying that you can get larger quantities of green or blue or yellow light at a cheaper price, though, of course, if you get enough bad light, it will serve after a fashion, as there will be enough red light contained therein to enable you to see; and, in my opinion, it is the use of glaring lights of improper color that occasionally punishes the eyes so by reason of the fierce reflection from all white surfaces, and makes one wish for two or three tallow candles for a treat. Therefore, neither quantity nor quality must be neglected when comparing values.

I say I was surprised to hear Mr. Swinburne say that light ought to be red. I always thought so, but did not think it was scientifically settled that way. I was surprised again when he discussed the mercury lamp, and said that as it was so deficient in red rays, it was very restful to the eyes. This, I think, can only be true in a certain sense. If you give up trying to work or read by it, of course it is restful, but you can do this to still better effect, probably, in total darkness.

In regard to the useful life of incandescent electric lamps, it is often stated to be best to over-run them, getting a largely increased quantity of light for a shorter life, and recent tests show that (on a quantitative basis only) this will pay when lamps are over-volted to an extent that will correspond with a consumption of power of 1.5 watts per candle-power. All this I fervently disbelieve. The light is much too "white," *i. e.*, deficient in red rays, approaching the color of the "highly efficient" open arc lamp, and suitable only for open-air treatment and for decorative purposes. The matter then resolves itself mainly, I believe, into a determination of the correct degree of incandescence permissible, and it would appear that nearly all materials are capable of being raised to such a temperature that the emitted light is useless for lighting purposes. If you hustle sufficient gas through a burner by compression you can get enough light from a "Welsbach" to frighten the most hardened electrician. Whether the extra cost of gas and mantles is "worth the candle" is what I want to know. My belief is that the effect is precisely the same as the over-volted incandescent electric lamp and some arc lamps, the light being decorative but useless.

Standardization and comparison of lights then should start with a determination by spectrum analysis of the constitution of the light emitted by the incandescence of each material, and this I am confident would lead to the immediate rejection of many lights that are now in use to the detriment of our eyesight. Incidentally, I think we should arrive at a more satisfactory understanding of the relative values of electricity and gas.

R. G. T.

LIGHTHOUSE WORK

The Electrical Engineer, July 27, 1906.

Sir:—Our attention has been called to the notice in your issue of the 13th inst. regarding the use of the Kitson light in lighthouses. We ask you, in fairness, that you will give us space to say that the notice contained in the *Times* is substantially

correct. That notice did not say that the Kitson light had superseded the electric; it stated that the Kitson light had been installed at the Lizard and other lighthouses. This information is absolutely correct. Further, the information that the Kitson system was used during a fog at the Lizard came from one of the lighthouse employees.

As to the question whether the electric light as installed at the Lizard is or is not superior to the Kitson system during a fog is not a matter of opinion, but a matter of fact. Any lighting engineer knows, whether he be an electric light man, a gas man, or an oil man, that the blue rays which preponderate in the electric arc will not penetrate the fog for any distance, whilst the red and yellow rays do, and as the Kitson system is rich in these it stands to reason that it should be a better illuminant during fogs than the electric arc. The same is true of the oil wick-lamp and an ordinary gas jet.

Permit us to quote the opinion of one of the greatest lighthouse authorities, Mr. John B. Wigham, of Dublin, who, in a paper read before the Royal Society of Dublin, said: "Recent experience has shown that the electric light is not the best light as a lighthouse illuminant, sea captains and others competent to judge having testified that it is misleading in clear weather, and absolutely useless in foggy weather. The Trinity House Corporation appear to have concurred in this view, for they have not established any electric light since the date of their report on the South Foreland experiments. The claims of the electric light as a lighthouse illuminant having thus been disposed of, the question arises: Can we find a light with the intensity of the electric light without its defects for lighthouse purposes? The new light, which I am about to describe, is one which seems to possess that desideratum; it is also rich in the red and yellow rays, in which the electric light is deficient, and it has, besides, the necessary volume which contributes to the power of making itself visible in foggy weather, and has also a uniform steadiness not attainable by the electric arc light. This light is an American invention, and is called, after the name of its inventor, the 'Kitson' light. It is really a gas light, though made from cold petroleum, and possesses those valuable properties which originally commended the gas system to Prof. Tyndall and the Irish Lights Commissioners."—Yours, etc.,

KITSON LIGHT FOREIGN SUPPLY CO.
(J. Chubb, Manager.)

[We are pleased to publish the above and to hear fully what our opponents have to say. The notice in the *Times* certainly left the impression that electric lighting had been abandoned for lighthouse work, which is not the case. As regards the penetrating power of red and yellow rays, this is proved to be greater in fog than that of the rays from the pure carbon arc. It would be interesting to test the flame arc lamp for lighthouse work, and to see how far the impregnated carbon's arc covers the penetration difficulty in times of fog. From experience in street-lighting, the flame arc should prove both the best light and also the cheapest.—ED. *E. E.*]

PROCESS FOR THE MANUFACTURE OF INCANDESCENT MANTLES WITH COPPER-CELLULOSE

BY W. BRUNO.

Zeitschrift für Beleuchtungswesen, July 20, 1906.

Incandescent mantles are made of cerium earths, together with thorium and zerconium oxides, cotton thread and Ramie fiber (Chinese Grass) being used as the oxide support. The thread is knitted into a hose, which is soaked in solutions of the cerium compounds, andwhen dry, cut in pieces about 20 cm. long. The cotton is then burnt out, and in a white heat the cerium salts turn into oxides. A little manipulation over the blowpipe will harden and form it and complete the manufacturing process.

Trials with many other natural oxide supports, like silk, hemp, etc., have been made, but with no success. Artificial threads were then employed, but as they do not readily absorb the solution, it is necessary to add the solutions of the cerium metals to the viscous substance, from which then the thread is pressed, so that it is impregnated and spun at the same time. This process was not bad, though rather complicated and expensive.

So far, only thorium nitrate has been used to obtain the oxide, because it has the highest surface tension. If a piece of thorium nitrate as large as a pea is placed in a platinum dish of about 20 ccm. capacity, the nitrate, on changing to the oxide in the heat, swells into a foam much beyond the capacity of the dish. This is the test of its quality, for it is believed not to shrink afterwards. However, the shrinking cannot be prevented altogether.

A new artificial thread has been made that may easily be impregnated, viz: copper-cellulose; it does not, however, combine with thorium nitrate.

A copper-cellulose mantle absorbs the thorium nitrate solution well enough, but on burning it the oxide is not formed, and it falls to pieces; the remedy is to substitute the hydroxide for the nitrate. This thorium hydroxide is a by-product in the manufacture of thorium. It is precipitated

when the acid solution is shaken with ammonia.

Unlike the nitrate, the hydroxide does not swell at a white heat, but shrinks together, is gelatinous, and instead of a loose powder it forms sharp, diamond-like crystals. It is not possible to impregnate a thread with it, but is necessary first to soak the copper-cellulose thread in the nitrate solution—just as with cotton or Ramie thread, and then convert it into hydroxide by means of an ammonia bath.

I have often thought when I saw the oxide manufactured from the hydroxide, why, in spite of the above-mentioned physical properties, it should be wholly impossible to use this chemically pure oxide in the making of mantles. Plaisetty, the Spaniard, has shown us, though, that it may be used with copper-cellulose to make a mantle that has surprising advantages over those till now made with thorium and zerconium.

The discovery must have been rather accidental, for who would think of using thorium hydroxide to impregnate a copper-cellulose thread, when it cannot be done with the nitrate solution, or when it has no effect on cotton or Ramie thread?

The old mantel is very hygroscopic, and this absorption of moisture causes much trouble, especially to the big dealers, since they get them in hose form, after having been impregnated with the salts, and do the finishing themselves. These new mantles, on the contrary, do not have this bad quality; if they are put in water for hours, there will not be the least oxalic acid found. This means an immense improvement.

There is a good apparatus in the market for testing the strength of mantles by percussions; an old one of good quality can stand 90-100 shocks, whereas the new copper-cellulose mantle can stand 2-3000, and be good still.

A microscopic photograph of a nitrate-oxide thread shows a mass of loosely twisted fibers, and that of the copper-cellulose thread a few untwisted wires.

As to the patent rights, it may be seen that it is easily possible to circumvent them, for instead of the specific method stated therein, to "treat the dry impregnated material with an alkaline bath," the thorium solution might, in order to obtain the hydroxide, be treated with hydrogen peroxide at 60° C., in an acid solution; and this process would not in the least interfere with the patent rights, and in fact gives still better results. The formula of the oxide obtained by this method, I am quite sure, is not, as commonly supposed, $Th\ O_2$, but $Th_2\ O_7$, and remains unchanged at the temperature of incandescence. The cerium also occurs in a corresponding form when hydrogen peroxide is used instead of ammonia, which, by the way, is a compound that is as yet little known.

CONCERNING THE TEMPERATURE OF THE NERNST LAMP

By Leon W. Hartman.

Physical Review, June, 1906.

The early determinations of the temperature of the incandescent glower of the Nernst lamp gave values which were undoubtedly much too high. These determinations were based on the law of the radiation from a black body. To this class of radiators, however, the Nernst glower does not belong, so that if the glower emits selective radiation as compared with the radiation from a black body, its measured black-body temperature might be much above its actual temperature. This is the case; hence the higher values of its temperature, as found by the early investigators, is explained.

If one avails himself of existing data and methods and applies the data and curves of Angström† to the data of the writer, already published,‡ a value of the temperature much lower than that cited by Lummer and Pringsheim§ will be obtained. This discrepancy then makes a determination of the temperature of the incandescent glower by direct measurement very desirable.

When the data for the energy losses from incandescent platinum wires in air had been obtained,|| an effort was made by the writer to utilize the same method for determining the temperature of the incandescent glower of the Nernst lamp. Briefly stated, this method was as follows: The candle-power per unit length for varying power supply was first determined with a number of Nernst glowers. In front of an iridium furnace containing a piece of magnesium oxide, was then mounted a frame for the glowers, in series with which was a suitable regulating rheostat. When the furnace was heated, the magnesium within was heated up to incandescence. Each glower in turn was then mounted on the frame and heated by a current until its color, as seen against the magnesium oxide as a background, seemed as near the color of the latter as it was possible to get it. Noting the power supply, the candle-power per centimeter length could be determined from the plotted curves of the first set of observations. As soon as the power supplied was determined, the temperature of the interior of the furnace—*i. e.,* the temperature of the magnesium oxide, was measured by means of a Wanner pyrometer. Some of the data thus obtained are given in the following table:

† Angström, *Phys. Rev.,* XVII., p. 302, 1903.
‡ Hartman, *Phys. Rev.,* XVII., p. 65, 1903.
§ Lummer and Pringsheim, *Verhd. d. Deutsch, Ges.,* III., p. 36, 1901.
|| Hartman, *Phys. Zeitschr.,* V., p. 579, 1904.

TABLE I.—MEASURED ENERGY SUPPLIED.

No.	Amp.	Volts.	Watts.	Watts. cm.	Temp. (abs.).	Watts. cm.	C.P.	C.P. mm.[2]
I.	0.148	173	25.6	16.3	2,360°	1.79	14.8	3.25
II.	0.410	182	74.6	36.1	2,360°	1.83	42.0	3.29
III.	0.846	175	148.0	52.9	2,360°	1.75	86.8	3.22
IV.	0.810	103	83.5	59.6	1,800°	1.90	47.0	3.36

In obtaining these data the writer had the co-operation and assistance of Prof. Nernst and one of his assistants, but at that time some doubt arose as to the accuracy of the temperature determinations thus made, and they have not been published hitherto. The writer has since decided to make some independent temperature measurements following an entirely different method, the details of which are given below.

When Prof. E. L. Nichols made his observations for the determination of the temperature of the acetylene flame,¶ it was the writer's privilege to assist in a small way. It seemed probable, therefore, that the same method used in those former measurements might be used to good advantage in determining the actual temperature of the incandescent glower when the latter was carrying a given constant load. Three specimens of the same platinum and platinum-rhodium wire used in the determinations just mentioned were therefore taken, pulled down to suitable size, and made into thermo-elements. After a 110-volt glower with its ballast had been mounted on a suitable frame, and connected in series with an adjustable rheostat, a current of 0.80 amperes—its rated normal load—was passed through the glower. The junction of the thermo-element was then moved slowly up to the incandescent glower. To the writer's surprise the junction could be brought in contact with the glower without melting or being otherwise visibly changed. This was true of the smallest junction used—the radius of which was 0.00360 cm. The only conclusion to be drawn was that the temperature of the incandescent glower was much lower than the early measurements indicated. The radii of the three junctions used were as follows: No. I. had a radius of 0.00592 cm.; No. II. of 0.00493 cm.; No III. of 0.00360 cm.

The thermo E.M.Fs. generated in these three thermo-elements were then measured on the potentiometer—the junction of the thermo-element being meantime in contact with the glower. From a curve, plotted from the values given by Kohlrausch,* the temperature corresponding to each E.M.F. was then read and a curve was plotted with corresponding temperatures as ordinates and cross-sections of the wires as abscissæ. In order to eliminate conduction, this curve was extended back until it intersected the axis of ordinates. Thus one eliminated the conduction of the thermo-elements, and obtained at the intersection of the curve with the axis of ordinates the value of the temperature that would be measured with a wire of zero cross-section. The values obtained from a series of measurements on a half-dozen different glowers gave results varying from 1,780 to 1,800 deg. absolute, as is shown by the following table:

TABLE II.—TEMPERATURES OF VARIOUS GLOWERS AS MEASURED WITH THE THREE THERMO-ELEMENTS.

Glower.	Temperatures for elements. No. I.	No. II.	No. III.	Exterpolated value.
I.	1,223°	1,407°	1,487°	1,505° C.
II.	1,220°	1,430°	1,500°	1,515° C.
III.	1,270°	1,425°	1,520°	1,530° C.
IV.	1,230°	1,385°	1,495°	1,535° C.
V.	1,145°	1,320°	1,460°	1,510° C.
VI.	1,150°	1,330° (?)	1,480°	1,515° C.
	Mean value............ 1,791° C. abs.			

In some cases the glower was heated by direct current; in others by alternating current. Sometimes the glower was in the plane formed by the two wires of the thermo-junction; sometimes the glower was at right angles to the plane including the two wires. In all cases the glower was horizontal. The mean of all these measurements gives a temperature of 1,791 deg. absolute.

After making these measurements, in order to make sure that the character of the wires of the thermo-elements had not been changed by contact with the hot oxides constituting the glower, the junctions were used to measure the temperature of various parts of the luminous cone of the

¶ Nichols, *Phys. Rev.*, X., p. 234, 1900.

* Kohlrausch, *Praktische Physik*, p. 157, 1901, 9th edition.

TABLE III. (COMPUTED).—WATTS PER CENTIMETER LENGTH REQUIRED BY BLACK BODIES FOR THE ABSOLUTE TEMPERATURES INDICATED BELOW.

No.	Thickness.	1,700°	1,800°	1,900°	2,000°	2,100°	2,200°
		Watts per centimeter.					
I.	0.0290 cm.	4.10	5.11	6.35	7.81	9.50	11.44
II.	0.0618 "	8.67	10.91	13.54	16.62	20.20	24.33
III.	0.0964 "	13.50	17.00	21.10	26.87	31.50	37.90
IV.	0.1000 "	14.10	17.60	22.00	27.00	32.70	.....

Bunsen flame. Values concordant with those obtained by Waggoner† were obtained. Although under a microscope the wires did not present a perfectly smooth appearance like that of a newly-drawn wire, yet the tests to which the junctions were subjected made it seem probable that the thermo-junctions used measured the true temperature of the Bunsen flame and of the glowers as accurately as one could expect, considering that there was more or less unavoidable change in the value of the current passing through the glower.

Some comparisons will now prove of interest. It will be instructive to compare the actual energy supplied to the glower when it is heated to a given temperature, with the energy required to produce the same temperature in a black body of the same dimensions as the Nernst glower. The computed data for the black body are given in Table III. For the absolute data temperatures indicated in this table, the energy per centimeter length required by a black body of the same cross-section as the Nernst glower is given. In Table I. data showing the energy supplied to four different glowers are given. The first three are German glowers and the accompanying data were obtained by the method first mentioned above, using the Wanner pyrometer and the iridium furnace to determine the temperature of the glower. The last case, glower No. IV., is one of the American glowers, in which case the temperature of the glower was measured by means of the thermo-element. Glowers Nos. III. and IV. of this table are so similar that a comparison is possible. For example, the current strength in the two cases, the watts per centimeter length, the energy per square millimeter, and the candle-power per square millimeter, are all of such a relative magnitude as to be comparable. In case of glower No. III., whose temperature was determined by the pyrometer, the temperature was found to be 2,300 deg. absolute. Judging from the candle-power per square millimeter glower No. IV. should be considerably hotter than glower No. III., but with the glower first mentioned the thermo-element showed a temperature of 1,800 deg. absolute. Evidently, therefore, the method used to measure the temperature of No. III. gave values much too high. In other words, the laws of Wien and Paschen do not apply to the Nernst glower, because it is not a black body, but, on the contrary, shows selective radiation when compared with the radiation from the latter. These laws cannot be used, therefore, with the constants now available for a black body, in order to determine the temperature of the Nernst glower.

If now we compute the energy lost by glowers Nos. I., II. and III., assuming for the time being that the black body law is followed and that the temperature obtained from measurements based on that law are correct, we find the watts lost per centimeter length to be relatively very small, as is shown by the first part of Table IV., and the percentage loss to be very small, ranging from 5 to 7 per cent. On the other hand, if we take the temperature obtained by the thermo-element method as the correct temperature of the glower, and then find the energy required to heat a black body of the same dimensions as the glower to the absolute temperature of 1,800 deg., we find a relative large loss—viz., 42 watts, or a percentage of 1,800 deg. absolute of 70.5 per cent.

The advantage from a commercial standpoint of rating the temperature of the Nernst glower above its actual value, is shown very clearly by these figures. From these considerations, it seems quite evident that the economic superiority of the glower over that of a black body is not so great as has been claimed for it. That it is far from being a black body, as has long been known, is also strikingly emphasized. That its true temperature has been placed too high is conclusive. Temperature measurements on the glower based on its radiating power or its photometric qualities, are alike apt to give values which are much too high.

TABLE IV.—WATTS PER CENTIMETER LENGTH LOST INTO THE AIR DUE TO CONDUCTION, CONVECTION, ETC.

No.	Absolute temps.	Watts lost.	Per cent. watts lost.
I.	2,360°	1.01	6.2
II.	2,360°	4.79	7.6
III.	2,360°	2.61	5.2
IV.	1,800°	42.00	70.5

† Waggoner, *Wied. Ann.*, LVIII., p. 579, 1896.

Miscellaneous News

AYER, MASS.—The Light, Heat and Power Company, having offices in room 808, Board of Trade Building, Boston, and of which Arthur E. Childs is president and Addis M. Whitney treasurer, has purchased the Royal Cheney farm of 63 acres, at Etill River, seven miles from here, for the purpose of erecting a central power station to furnish light and power for the towns of Leominster, Clinton, Ayer, Harvard and Groton. The central plant is expected to cost about $80,000.

BOSTON, MASS.—In response to the demand made by organized labor, Mayor Fitzgerald called upon the Edison Electric Illuminating Company for arbitration of the city's contract with the company, to determine whether the city is entitled to a reduction in the price it is now paying for electric lighting. If such arbitration had not been called for before the latter date, the city would have been obliged to continue to pay the present rate of $125 per lamp per year for two and one-half years longer. It is believed that a reduction of this rate will be obtained.

CAMDEN, N. J.—The City Council has decided to submit to the people the question of municipal ownership of its own electric light, heat and power plant, as authorized by the recent Legislature. A resolution was adopted providing for a vote on the subject at the general election on Tuesday, November 6.

COLUMBUS, O.—The United States Court has sustained the injunction which stops the City Council of Columbus, Ohio, from forcing the Columbus Railway and Lighting Company to limit its charges for electric light and power to not more than five cents per kilowatt hour. The ordinance fixing that rate was passed by the Council in 1904. The company resisted the reduction, alleging that the new price would not allow any profit on its investment. It was shown by the evidence that the five cents per kilowatt hour rate would require the company to furnish electricity at cost to 75 per cent. of its patrons and at less than cost to most of the others. The Court concurred in the opinion that this amounts practically to confiscating property and is in violation of the Federal Constitution. While the City Council has the right to fix the charge for electricity it cannot put it so low as to leave no fair return on its investment to the electric company. The injunction against the City Council is made permanent.

EMPORIA, KAN.—The special committee appointed to investigate the matter of establishing a municipal plant for lighting the streets in connection with the water plant has reported to the effect that such a plant will afford street lamps at a cost not to exceed $4 per light per month.

HARTFORD, CONN.—In the merging of the Windsor Locks and Enfield Electric Lighting companies into the Northern Connecticut Light and Power Company, it is said that the present plant of the local company, which is totally inadequate to meet the demands upon it, will be torn down in the fall and a new and larger station erected. The new company will also erect a gas plant at Thompsonville, and after the building operations are settled upon, the concern will be re-capitalized.

NEW YORK CITY.—The Borough of Richmond (Staten Island) is agitating the question of a municipal lighting plant. Much complaint is heard of the poor service given by the Richmond Light and Power Company, who are now supplying the light. The present lighting company gives as a reason that the city owes it half of a million dollars and cannot make improvements until this amount is paid.

ONEIDA, N. Y.—After January 1, 1907, this will be one of the cheapest lighted cities in the State of New York. The contract for lighting for two years from that date has been let to the Empire State Power Company, which was the lowest bidder at a rate of $37.50 for all night lamps and $25.00 for one o'clock lights. This is one-half the rate paid at the present time.

ROCHESTER, N. Y.—The city is advertising for contracts for furnishing electric lights for the streets. The conditions of the contract are such that outside lighting companies may compete, as it is provided that bids may be made to deliver current at the city limits. It is hoped that in this way the Niagara Falls current may be able to compete with the local company, which at present has a monopoly.

SIOUX CITY, IA.—The contract has been let and work already has been begun on a power house for Sioux City Service Company. The building will be of concrete, one story in height, and will be 75 by 78 feet in dimensions. The estimated cost of the building is $30,000. The entire cost of the improvements, however, will be larger when the entire amount spent in equipping it is figured. John P. Wall has the building contract.

WATERTOWN, N. Y.—City Attorney Breen has applied to the Common Council for authority to employ a hydraulic engineer to estimate the valuations of water powers along the Black River, with the idea of using them for a municipal lighting plant.

HOTEL BELMONT,

CORNER FOURTH AVENUE AND FORTY-SECOND STREET, NEW YORK.

The
Illuminating Engineer

Vol. I. SEPTEMBER, 1906 No. 7

Practical Problems in Illuminating Engineering

VII. ILLUMINATION OF A BANKING HOUSE

By Arthur A. Ernst.

The present problem, like the one we last described, involves no complicated engineering work nor unusual conditions, but is a fair example of a case which is exceedingly common, viz., a modern building, erected and furnished with unstinted expenditure, but in which the artificial illumination is found to be inadequate after it has been put to the test of practical use. The building in question is 62 Cedar street, New York City, and is occupied by the banking house of Harvey Fisk & Sons.

The ground floor is occupied by public and private offices, a mezzanine running about three of the side walls. It is finished with white marble wainscoting, the walls and ceilings above which are of a light cream color. The carpets are of an olive green, and the furniture of mahogany. The entrance hallway contains three large globes made up of bead glass work. The balance of the general illumination was originally furnished by 16-inch glass bowls frosted on the inside, and placed in fixtures against the ceilings, each bowl containing eigh 16-c.p. incandescent lamps. The fixtures were 12 and 14 feet apart, and the ceiling height 13 feet. All desks are supplied with individual desk lamps with reflector shades.

It was found, however, that the general illumination was insufficient, and the problem to be solved was to find a simple method of increasing the illumination without introducing additional fixtures requiring separate wiring, and if possible, without increasing the current consumption. In other words, all changes were practically limited to glassware, lamps and fixtures.

As the proprietors wished to make a demonstration of the proposed method before making changes throughout, a single office on the ground floor was assigned for this purpose.

The office is shown in plan in Fig. 1, and in sections in Fig. 2.

The faults of the original installation were as follows:

(a) Absorption of light by the frosting of the bowls;
(b) Loss of light by the absorption of the upward rays in the fixture;
(c) Low efficiency of the lamps used;
(d) A light distribution unsuited to the special requirements;
(e) Overheating of the lamps, with consequent shortening of life and decrease in candle-power.

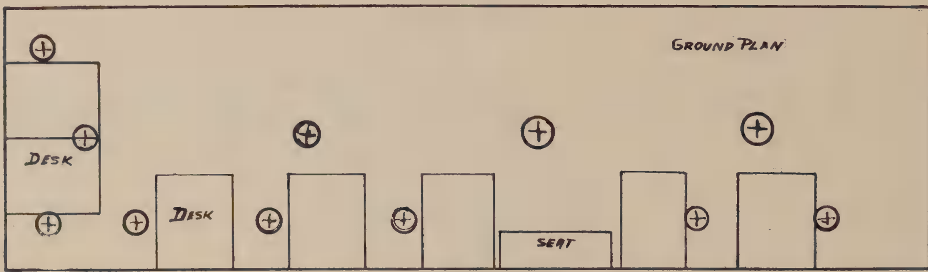


FIG. I.—GROUND PLAN OF OFFICE.

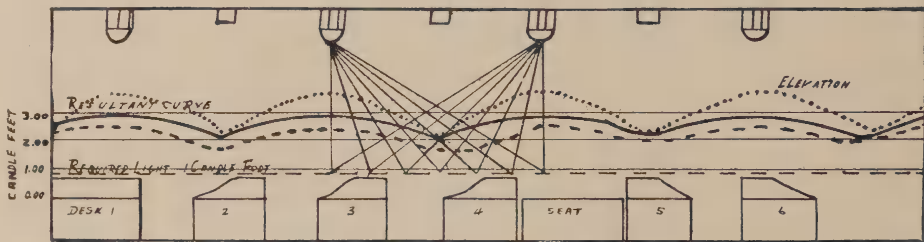


FIG. 2.—VERTICAL SECTION, WITH ILLUMINATION CURVES.

To correct these faults the following means were used:

(a) The substitution of Holophane Hemispheres for the ground glass bowls;

(b) The use of prismatic reflectors to cover the hemispheres;

(c) The substitution of a single 100-c.p. GEM lamp for the eight 16-c.p. lamps;

(d) The use of prismatic reflectors to increase the downward distribution;

(e) Dropping the hemispheres two feet below the ceiling to give ventilation.

The difference in absorption between ground glass and holophane globes may be assumed as 15% of the total light, and the gain by utilizing the upward rays by the reflector would probably represent 30%; the use of a single lamp of 100 rated candle-power in place of the eight lamps having a rated candle-power of 128 would, therefore, be fully justified. By this change in lamps a reduction in current consumption of 44% was effected—assuming that the 16-candle-power lamps were of 3.5 watts efficiency. This amounted to a saving of 200 watts for each fixture. By dropping the fixtures a greater intensity of illumination at the level of the desks was obtained, while at the same time the small portion of light transmitted by the reflector was sufficient to prevent perceptible darkness on the ceilings.

The curve of distribution of the Holophane Hemisphere, fitted with the single lamp and reflector, is shown in Fig. 3, the curves of horizontal intensity on the assumed plane being given in the lower part of the diagram. Curve B is the illumination produced by a single source. Curve B′, the illumination between two sources 14 feet apart, and curve C the illumination between two sources 12 feet apart.

It should be observed that these curves do not take into account the light from more than two sources, nor reflection from side walls and ceilings. Omitting the curve of illumination produced by a single source, it will be seen that for units 14 feet apart the maximum illumination is 3.3 foot-candles, and the minimum illumination 1.75 foot-candles, while with units 12 feet apart, the minimum is raised to 2.3. As 2 foot-candles furnished a fairly good light for reading, this intensity was deemed sufficient. In carrying out the specifications for the

fixture, a simple but substantial design, consisting of a band holding the hemisphere supported by four chains from a canopy on the ceiling, was constructed by the manufacturer.

The illumination produced by these changes was found to be satisfactory, and similar changes were made throughout the other offices.

In order to check up the theoretical results, illuminometer measurements were recently made. In some fixtures the lamps were practically new, while in others they had been in service for some time. The curves of illumination obtained are given in Fig. 2, the upper curve (dotted line), showing the illumination with new lamps, and the lower curve (broken line), the illumination with lamps that have been in use. It will be seen that the theoretical curve lies between the two. From this it appears that the original calculations were very close to the actual results; the additional intensity shown with the new lamps might be easily accounted for by additional light from other sources, as well as the general reflection from the walls and ceilings, and it would be expected that the illumination would fall somewhat below the theoretical value with lamps that have been some time in use.

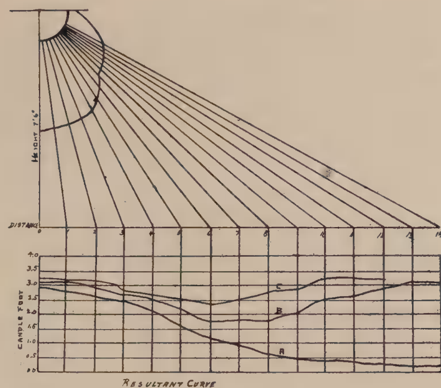


FIG. 3.—CURVES OF DISTRIBUTION AND HORIZONTAL INTENSITY.

VIII. COMBINATION OF INCANDESCENT GAS WITH ELECTRIC LIGHT

This combination has been usually, and very rightly, condemned for general practice on account of the contrast in color between the two sources. As the light of the electric lamps is orange in tint, and that of incandescent gas of a greenish yellow, the two are nearly complimentary colors, and thus exaggerate their difference in tint when used in juxtaposition. In the present instance, which involved the lighting of the office and other public rooms of one of the older hotels, the principal object was to reduce the cost. The general illumination in the lobby was by bare 16-c.p. lamps studded about the panels of the ceiling. A broad staircase leads from the lobby to the second floor, and the newel posts at the landing and upper floors provided with standards supporting 5 gas burners. As gas was still available throughout the building, it occurred to the writer that a satisfactory illumination of the staircase at a considerable reduction in cost could be secured by the use of incandescent gas burners on the newel post standards. The writer was aware that, a number of years ago, the Holophane Glass Company had placed on the market a series of globes for incandescent gas burners made of a special glass having a light salmon-pink tint. These were made for the special purpose of harmonizing the color of incandescent gas light, with that of the incandescent electric lamp. Upon inquiry, it was found that the company still had a few of these globes in stock, and they were therefore brought into use, 7-inch spheres being specified. The result was highly satisfactory from the color point of view, as the difference was not sufficient to be noticeable to the ordinary observer. The additional absorption of these tinted globes is very small, as the color is thoroughly transparent.

In view of the success of this experiment it seems rather curious that these tinted globes never found any considerable market and were finally withdrawn entirely by the manufacturers.

PRIVATE SUITE: PARLOR.

The Illumination of the Hotel Belmont, New York City

The Hotel Belmont may fairly be described as the first "skyscraper" hotel to be erected. As the illustration used as a frontispiece shows, the building has twenty stories above ground, and there are four stories underground. The Subway runs through a corner of one of these lower stories, there being one story still beneath the Subway level. This entire subterranean space was excavated from the solid rock.

The exterior architecture is of a non-committal character, little attempt being made at decoration, or carrying out of any particular architectural type, what little attempt there is in this direction follows classic lines. The general interior architecture is characterized by the same simplicity and freedom from ostentation and attempts at gaudy decorative effects.

The lobby, shown on the front cover, is nearly square in plan, and two stories in height, with a mezzanine or gallery running about three sides. The lighting of the lobby is by means of massive lanterns suspended from the centers of the ceiling panels, as shown in the illustration cover, and in detail in Fig. 1. These lanterns have one peculiarity of construction: the lamps are all on the outside. In place of the transparent glass windows usually provided, the spaces are filled up with strips of mirror glass. The images of the lamps seen in these mirrors give the effect of lamps within the lantern. The central lantern is supplied with eighty 16-c.p., 2½-inch

FIG. 2.—READING ROOM ADJOINING LOBBY.

FIG. 3.—LADIES' PARLOR.

round frosted lamps. The four smaller lanterns suspended at the corners of the central panel are of similar design, but support thirty-six lamps of the same size and shape. In addition to this lighting, cove lamps were provided to furnish "concealed light" on the ceiling within the panels, but it has been found necessary to use them at least on ordinary occasions. The entire ceiling is of light stone color, and penciled off to represent masonry, the beams being apparently supported by sculptured brackets, as shown. In addition to the light from the lanterns, the pillars are furnished with side brackets, each supporting nine 2½-inch spherical frosted lamps. These brackets are of handsome design, as shown in Fig. 2, the crown and support being of bronze, and the standard covered with maroon velvet, with a tassel at its junction with the crown.

The space under the mezzanine on either side of the lobby is used as a reading room, and is lighted by means of bronze lanterns containing ten 16-c.p. lamps, and side brackets of the same pattern as those in the lobby.

"THE GARDEN."

RESTAURANT

FIG. 4.—LARGE LANTERN IN LOBBY.

A hallway running the full height extends from the lobby to the restaurant on the Forty-first street side of the building. The elevators are located in this hallway, directly opposite the Fourth avenue entrance. Lanterns of the design shown in Fig. 4, are suspended from the ceiling of this hallway. In addition to the lanterns, incandescent lamps are placed in the dental course surrounding the central ceiling panel, and three-light side brackets carrying 3 round frosted lamps are placed between the elevators.

The restaurant at the end of the hallway is of full two-story height, flanked on three sides by the mezzanine. The ceiling contains a large central panel with three smaller panels on each side. The walls and ceiling are frescoed in light tints, the prevailing color scheme being cream color, light blue, and gold. From the central panel a massive crystal chandelier is suspended, as shown on page 504. This is plentifully supplied with 16-c.p. lamps, the exact number of which we were unable to ascertain. In each of the six side panels of the ceiling there is a crystal fixture having the general form of a bowl, attached to the ceiling. Brackets, also of crystal, are attached to the side walls. These brackets contain small, clear, round lamps, fitted with star-shaped glass shades. The effect of these brackets is very pleasing, the brilliancy of the bare filaments, caught up and reflected by the star-shaped shades and cut-glass ornaments, suggesting the sparkling of diamonds, or twinkling of stars.

Adjoining this dining room at a right angle is another dining room called by the management "The Garden." This is also of two-story height, and decorated in the style of Louis XIV. There is a central dome in the ceiling, frescoed in color, while the remaining decorative effect depends upon the use of the characteristic de-

FIG. 5.—WRITING ROOM ON MEZZANINE.

FIG. 7.—CAFÉ.

FIG. 6.—BUFFET.

sign of the period, in cream color and gold. Lamps are set in the dental course surrounding the dome, while from the panels on either side crystal chandeliers, of the general design of those in the restaurant, are suspended, as shown on page 504. The "Garden" is reached by a hallway leading off of the longer hallway previously mentioned nearly opposite the Fourth avenue entrance. This hallway is lighted by side brackets of the type used in the lobby. Where there is not wall space to attach the side brackets, the same design is worked into a standard, of which there are several in the hallways.

The mezzanine is reached by a broad stairway located at the Fourth avenue entrance. The portion about the lobby is used for writing and reading rooms, and is lighted by three-light side brackets equipped with three-inch round frosted lamps, as shown in Fig. 5. The portion flanking the restaurant is lighted with a specially designed crystal wall fixture, which consists of a projecting shield composed of cut-glass prisms and jewels, behind which are placed three 16-c.p. lamps. From this mezzanine, stairways lead to the second floor proper. These stairways are lighted by large bead-work spheres.

The Ladies' Parlor is located on the Fourth avenue side of the second story, and is shown on page 502. The lighting here is by ceiling fixtures of crystal, and side brackets, also of crystal—each supporting five opal glass "candles," tipped with frosted lamps.

The buffet and café are located in the basement. The former is a square room with low vaulted ceiling, finished in light buff, with a wainscoting of light gray oak running about the four walls. The illumination is by wrought-iron fixtures suspended from the points of the arches, each fixture supporting eight 6-inch Holophane globes, and side brackets on the columns. In the café, the illumination is entirely by side brackets of wrought iron, each supporting three 3-inch frosted spherical lamps in an upright position. These two rooms are shown on page 506. This concludes the list of rooms for the general use of the guests, there being no special dining or assembly rooms.

The guest rooms are illuminated by both central chandeliers and side brackets, the general type of chandelier having the form shown on page 502, which is a view of one of the parlor suites. The finish is of Flemish brass, and on both brackets and chandeliers the lamps are in a pendant position, and covered with frosted glass shades. All rooms, whether large or small, are supplied with a central chandelier containing from three to seven lights according to the size of the room. There is likewise in every room, a bracket on each side of the dresser, another near the head of the bed, and a two-light bracket immediately above the mirror over the washbowl. Closets are also provided with lamps in the ceiling. In the hallways, the lighting is by pear-shaped globes of frosted glass, supported by a metal fixture placed against the ceiling and containing a single incandescent lamp. The ceilings of the hallways are cream color, the side walls of a light neutral tint, and woodwork, dark mahogany, and the carpeting of a dark green shade.

From the above description of the fixture installation, and from the illustrations given, it will be seen that in no case has an attempt been made to produce unusual or scenic effects. The sole purpose of the architect was apparently to furnish adequate illumination, both as to quality and intensity, by the use of fixtures designed to harmonize with the general scheme of architecture and decoration. In general, the results afford very little opportunity of criticism from the standpoint of the illuminating engineer. There is a plentiful use of spherical frosted lamps, which produce an illumination that is soft and agreeable to the eyes, although not in the most economical manner; but this is plainly a case in which economy is not of primary importance. The illumination, with one exception, is sufficient in every case, without being excessive. In several instances more illumination was provided than it has been found necessary to use.

The illumination provided for the guest rooms is especially worthy of praise. By the combination of side brackets, central chandeliers, and table lamps, it is possible for a guest to arrange the illumination exactly to suit his tastes and needs. The brackets on each side of the mirror provide an ideal light for dressing; the central chandelier gives general illumination, while the table lamp and side brackets afford particularly good illumination for reading, even for those addicted to the habit of reading in bed.

In only one respect is there occasion for serious criticism, and that is in the lighting of the hallways of the guest room floors. The fixtures in this case obscure the downward light so as to leave the floor in perceptible shadow, while giving the maximum intensity about the height of the transoms, through many of which the light can shine directly into the rooms. The latter, however, is mitigated somewhat by the low intensity of the light, even in this direction.

Taken as a whole, the fixture equipment is in excellent taste, and does credit to the designers, the Sterling Bronze Co., of New York.

Plain Talks on Illuminating Engineering

II. LAWS OF LIGHT

By E. L. Elliott.

Under certain conditions light behaves in a certain definite way, and the manner of its behavior under these conditions is commonly referred to as a "law." There are a number of these laws which form an important part of the basis of Illuminating Engineering, and with which we must therefore become familiar.

First Law. *Through a given medium light travels in straight lines.*

By a "medium" is meant simply that through which a light passes, which may be any transparent substance. Air and glass are the only media with which we need to concern ourselves. A beam of light from a search-light is a familiar illustration of this law, while the straight lines of projected shadows is another common example.

Second Law. *Light radiates in every direction from its source.*

This law is commonly stated in text-books substantially as follows:—"From a given source, light proceeds equally in all directions." The misconception of this statement of the law has perhaps led to more mistakes and incongruities in the use of light than any other single error, and it will, therefore, be well to study the matter carefully in order to avoid falling into the same erroneous conclusions. The source of error in the textbook version is in the statement that "light proceeds *equally* in all directions from a source." This would be true if the source of light were a point, but a point being defined as "that which has neither length, breadth nor thickness," it is evident that no actual light-source can fulfil these conditions. Points exist only in the imagination; and while they are absolutely necessary as conceptions for purely mathematical work, they must not be confounded with the actual surfaces which form the real light-sources with which we have to deal. Such luminous surfaces give out light in all directions, but with a greater or less degree of *in*equality in different directions, depending upon their size and shape. Take, for example, the ordinary flat gas or oil flame. If you look at the flat side of the flame, you will evidently get a stronger light than if you look at the flame edgewise. Again, take the case of the incandescent electric lamp. The source of light is the surface of the carbon filament, and this surface may be considered equally luminous at every part.

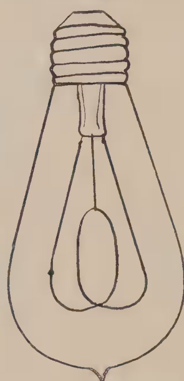


FIG. I. SIDE VIEW OF LAMP FILAMENT.

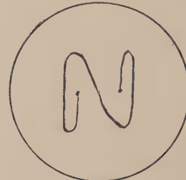


FIG. 2. "END-ON" VIEW OF SAME FILAMENT.

The intensity of light from the filament will then, as in the case of the gas lamp, depend upon the direction in which it is taken. Thus, taking the ordinary "oval anchored" filament lamp, and holding it so as to look at it sidewise, the filament appears as in Figure 1. If you turn the lamp so as to look at the tip end of it, the filament appears as shown in Figure 2. A much greater surface of filament is visible in the first position than there is in the second, and as a consequence a stronger light is given out in the

direction shown in Figure 1. In other words, the lamp gives out a stronger light in the horizontal direction than it does through the end. In various other positions it would give out correspondingly varied intensities. There is nothing at all mysterious or intricate about this simple fact of light-sources distributing their light unequally, and it is rather remarkable that the fact should have so long been overlooked in the application of light to illumination. It is only very recently that the matter has received the importance due to it, and is still very inadequately understood and appreciated by the majority of users. It is still customary to give the light-power, or "candle-power" of a source by the measurement of the light given out in one direction. This and other considerations of the manner in which light-sources distribute their rays will be more fully discussed when we come to the measurement of light; meanwhile, let it be fixed in the mind that light-sources do *not* give out their rays equally in all directions.

THIRD LAW. *The intensity of light varies inversely as the square of the distance from the source.*

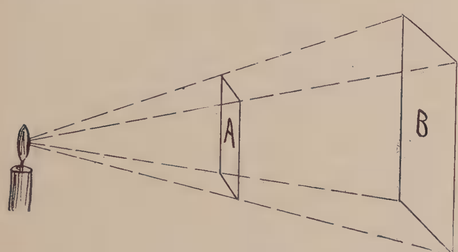


FIG. 3.—LAW OF INVERSE SQUARES.

This is the familiar "law of inverse squares"—a law which not only applies to light, but also a great many other natural phenomena. The meaning of the law can best be understood by the use of a diagram. In Figure 3, suppose the light source placed at *L*, and suppose a surface placed four feet away, as at *A*; a certain amount of the rays will fall upon this surface, and will illuminate it with a corresponding intensity. Now, if there be another surface eight feet from the source, represented at *B*, it would be found that the shadow cast by the surface *A* upon the surface *B*, would have just four times as great an area as the surface of *A*—or, what is the same thing, if the surface *A* were removed, the light which fell upon it would cover four times as great an area upon the surface *B*, which is twice as far from the light-source. Since the same quantity of light falls upon four times as much surface, it is evident that the illumination of the surface would be only ¼ as bright; *i. e.*, at twice the distance, the intensity or brightness of the light is ¼ as great. In the same way it can be shown that at three times the distance, the intensity would be 1/9, and so on. It will be seen that as the distance grows *greater*, the intensity grows *less*, which is the meaning of the expression, "varies inversely"; and further, that the number representing the fractional part is the *square* of the number representing the *distance.*

Strictly speaking, this law holds true only when the source of light is a point; this means that it is never absolutely true in practical cases. The error diminishes with the distance from the source, and as in most practical cases the distance of the illuminated surface is large compared with the size of the source, the error is trifling. With some of the newest light sources, however, such as the Moore Vacuum Tube Light, and the Mercury Vapor Lamp, the size of the source is sufficiently large to very materially modify the application of the law. Another point to be remembered in connection with it is, that it is understood always that the intensity of the light is to be taken on a surface perpendicular to the rays. If the surface is inclined it can be very readily seen that the conditions would vary. Thus, in Figure 4, the light which covers the surface *C*, at right angles to the rays, would cover the surface *D*,

which is much larger, having an inclination to the rays. The exact law of this difference requires the use of higher mathematics, and we will therefore omit it.

FOURTH LAW. *When light passes from one medium into another, it changes its direction at the dividing surface between the two.*

This change of direction is called Refraction. The appearance of a post

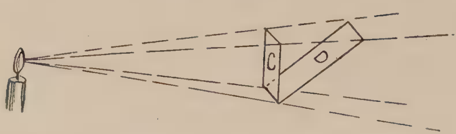


FIG. 4.—DECREASE OF ILLUMINATION ON INCLINED SURFACE.

standing in water of being broken or bent at the surface is due to this law. A full statement of the law requires the use of higher mathematics, and its application is not of sufficient importance in practical illuminating engineering to render a further discussion necessary.

FIFTH LAW. *Whenever light falls upon the surface of a body a portion of the rays are reflected: the direction of these reflected rays is such that the angle of reflection is equal to the angle of incidence, and in the same plane.*

The various facts referring to reflection are among the most important in the whole subject, and therefore require careful study. Again, we may

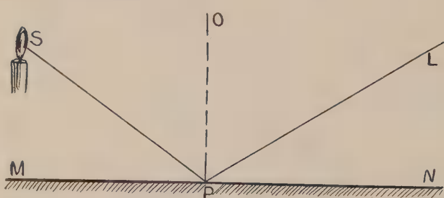


FIG. 5.—LAW OF REFLECTION.

best explain the meaning of the law by reference to a particular case. Suppose *MN* Figure 5 is a surface, and a ray of light falls upon it from a source *S* in the direction *SP*. Imagine a line at *P*, perpendicular to the surface. The angle *SPO* is the angle of incidence. Now, the law states that this ray will be reflected in a direction *PL*, such that the angle *OPL* shall equal the angle *SPL*: the angle *OPL* is the angle of reflection. Furthermore, the law states that these two angles are in the same plane, *i. e.*, a plane based through the perpendicular *OP* and the incident ray *SP* will also pass through the reflected ray *PL*. If difficulty is found in conceiving the relative positions of these lines, planes, and angles, the use of a sheet of paper to represent a plane, upon which the lines or directions of rays may be drawn, will assist in making the matter clear. It will be noted that the angles are measured, not directly with the surface from which the reflection takes place, but with a line drawn perpendicular to that surface at the point where the rays strike. This is always understood, and is done for mathematical reasons. Furthermore, it

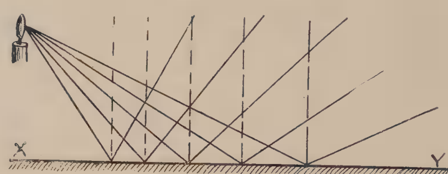


FIG. 6.—REGULAR REFLECTION.

must be understood that the statement of the law given is mathematical, *i. e.*, it applies to single rays of light striking plane (smooth), surfaces.

In actual practice, however, plane or smooth surfaces are less frequently met with than irregular or rough surfaces, and we do not, except for purposes of pure mathematics, deal with rays of light, but with beams or quantities. While all of the effects of reflection result from the single law stated, the results are often apparently very different from what would naturally be expected.

Let us first examine the case of reflection from a plane surface. Suppose such a surface be represented by the line *XY* in Figure 6, and assume that light rays fall upon it in different directions, as from a source placed at

L. Applying the law to each separate ray, we find that their direction after reflection will be as shown. Examination of the reflected rays will now show that their directions *relative to one another* have not been changed, *i. e.*, if they were parallel before reflection, they remain parallel after reflection, or if they were at an angle to one another before, they will have the *same* angle after. Without going further into details, it may be stated

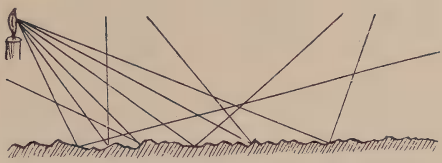


FIG. 7.—IRREGULAR REFLECTION.

that it is such reflection as this that produces images of objects, such as are seen in a mirror.

Now let us see what will happen if the surface is rough. Roughness simply means that the surface is covered with more or less minute elevations and depressions. A line drawn across such a surface might be as shown in Figure 7. Now suppose rays fall upon this surface as in the previous example. Each ray may strike a different small surface, and at a different angle, and will be reflected from the small surface which it strikes in accordance with the law given. It is evident that the reflected rays will have varying directions relative to one another due to the varying angles of the surface from which they are reflected. The total result of a beam of light falling on such a surface therefore, would be to scatter it in all directions after reflection. The two cases may be clearly shown by letting a beam of light fall upon a mirror, in which case the light will still retain its original form of path after reflection, the direction only being changed; then let the same beam of light fall upon a rough surface, such as a sheet of white paper, and the result will be a scattering of the light in every direction from the surface.

Light thus scattered, *i. e.*, composed of rays traveling in all directions, is called Diffused light.

From the two cases given, it will be seen that, so far as their reflecting quality is concerned, all surfaces may be divided into two classes, which may be termed Regular and Irregular, or Smooth and Matt.

Reflection from regular or smooth surfaces may accordingly be termed Regular Reflection (also sometimes called Specular reflection), and that from rough, or matt surfaces, Irregular or Diffuse reflection.

No actual surface is theoretically regular, or plane. The surface of still water, and of the best polished mirrors approximates it to a high degree; but if it could be made absolutely plane, it would be impossible to see it. On the other hand, no surface is perfectly matt. By a perfectly matt surface is meant one which would reflect a beam of light falling upon it equally in all directions. As a matter of fact, all surfaces produce some regular reflection, *i. e.*, they will reflect somewhat more light in a regular way than they do in a diffused way. Thus, even the surface of white plaster or unglazed porcelain gives some regular reflection. A surface is polished or "shiny" to the extent to which it gives regular reflection, and even the plaster or porcelain surfaces men-

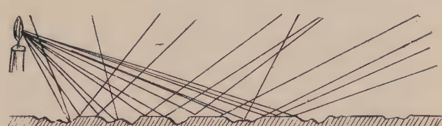


FIG. 8.—REGULAR AND IRREGULAR REFLECTION.

tioned will appear slightly shiny in the line of direct reflection.

The cause of the shiny appearance on surfaces may be easily explained by a further consideration of the cases just described. Referring again to Figure 6, a perfectly matt or rough surface would have the same number of small surfaces at every possible angle, and such a surface would, there-

fore, reflect a beam of light falling upon it equally in all directions; but suppose now that the tops of the projections are flattened down, or ground off, as represented in Figure 8; then each one of these flattened tops will reflect light like a plane surface, *i. e.,* will give regular reflection, and if looked at in the line of direct reflection will appear bright or shiny. The more the small projections of the general surface are flattened down in this way, the greater the amount of plane surface and of direct reflection, in the one direction, and hence the shinier the surface will appear. Even in the most unpolished, or matt surface, such as those mentioned, there is a slight preponderance of these small surfaces in the same plane, and hence some direct reflection; and in the most perfectly polished surfaces it is impossible to entirely remove the depressions or irregularities, and hence there is always some irregular or diffused reflection.

It was stated that when light falls upon a substance, a portion of it is reflected, and the remaining portion absorbed, by the body. The absorbed light is converted into heat. The ratio of the light reflected to the amount of light received, is called the co-efficient of reflection. Thus, if half of the light is reflected, the co-efficient of reflection is .5. The co-efficient of reflection depends upon the following conditions:—

The material of which the surface is formed;

The nature of the surface (degree of polish);

The angle at which the light strikes the surface;

The color of the light striking the surface.

As any one of more of these conditions may vary, it will be seen that reflection is a complex action. So far as illumination is concerned, however, these complexities need not be considered to such an extent as to be confusing.

We will consider the different conditions in the order given. We learned in the proceeding article that ordinary light is in the nature of a compound, being made up of rays of different colors. Different substances absorb different rays in the reflection of compound light; thus, some substances will reflect the red rays very completely while absorbing nearly all of the other colors; in a similar manner other substances will reflect a large proportion of the green rays while absorbing the red and other colors. Since we see things by the light which they reflect, it necessarily follows that substances which reflect only the red rays will appear red, and those which reflect green rays, green, and so on for any other color or shade. It thus appears that the color of non-luminous bodies is entirely due to their peculiar powers of absorbing a part of the rays and reflecting the others. All substances, however, reflect some of all colors, and also absorb some of each color.

Difference in reflection due to the difference in the character of the surface is a matter familiar to all; for example, a polishing surface will cause it to reflect a greater amount of light. It does not follow, however, that all polished surfaces are uniformly better reflectors than all matt surfaces. A matt surface, which reflects all the color rays about equally well, *i. e.,* a white surface, may give as much total reflection as a highly polished surface of some other material. The surface of fresh white plaster, for instance, is practically as good a reflector as the ordinary glass mirror.

In general, the more obliquely the light strikes the surface, the greater the amount of reflection. In the case of polished surfaces, the difference due to the difference in the angle of incidence is greater than in the case of unpolished surfaces.

From the fact above stated, that different substances absorb the various colors to different degrees, it must follow that the total amount of reflection from a given surface will depend upon the colors in the light striking it.

Thus, suppose a red surface, *i. e.,* one which reflects red light and absorbs the green; if only green light fell upon such a surface, it would be entirely absorbed, making the surface appear black, while if red light fell upon it, it would be more or less completely reflected, giving the surface its usual red color.

The diffused reflection from the walls and ceilings of a room is an important item to be considered in dealing with its illumination. In order to determine to what extent such reflection should be taken into account, let us consider a theoretical case. Suppose a single light-source placed in a room: this source will give out its light in all directions, and every ray will reach some point on the surface of the walls; from this point it will be reflected to some other point, from which it will be again reflected, and so on indefinitely until it is all absorbed. It can be demonstrated mathematically that the increase in illumination produced by this reflection and re-reflection of the rays is as represented in the following formula:—

Increase of illumination equals one divided by one minus the co-efficient reflection of the walls. $I = \frac{1}{1-C}$

For example, if the walls reflected one-half the light, *i. e.,* if the co-efficient is .5, the increase in illumination due to this reflection will be $\frac{1}{1-\frac{1}{2}} = 2$, *i. e.,* the reflection from the walls will double the intensity of illumination at any given point in the room.

In order to determine the actual results of the reflection from walls and ceilings, therefore, it is necessary to know what portion of the light they reflected, or their co-efficient of reflection. This quantity may vary anywhere from .1 to .8, according to the character of the decorations or wall coverings. While the formula given is mathematical, it is never possible to obtain any but approximate results, since, even the exact co-efficient of the walls were known, which is rarely the case, the effect of openings, such as doors, and windows, and surfaces of furniture, etc., would prevent any high degree of accuracy. The difference between walls having a light color, and a correspondingly high co-efficient of reflection, and those of a dark color, however, is sufficiently large to render the matter of importance.

SUMMARY.—LAWS OF LIGHT.

First Law. *Through a given medium light travels in straight lines.*

Second Law. *Light radiates in every direction from its source.*

The intensity in different directions varies on account of the varying shape of the luminous surface of the source.

Third Law. *The intensity of light varies inversely as the square of the distance from the source.*

This law does not hold strictly true when the luminous surface of the light source is large as compared with the illuminating surface.

Fourth Law. *When light passes from one medium into another, it changes its direction at the dividing surface between the two.*

Fifth Law. *Whenever light falls upon the surface of a body a portion of the rays are reflected: the direction of these reflected rays is such that the angle of reflection is equal to the angle of incidence, and in the same plane.*

Reflection of light in general is either *Regular* or *Irregular;* regular reflection is that which forms images, or gives a shiny appearance to surfaces; irregular reflection is that which scatters the rays in all directions, giving a diffused illumination. Regular reflection is also called *Specular Reflection,* and irregular reflection, *Diffuse Reflection.* The word *Diffusion* alone is sometimes used to mean light irregularly reflected.

The color of non-luminous bodies is due to their absorption of a part of the color rays, and the reflection of the others. The color of the body is the color of the rays reflected.

The proportion of the light reflected to the total light received is called the *Co-efficient of Reflection.*

The amount of light reflected depends upon the material, the kind of surface, and the angle at which the light strikes. Least light is reflected when it strikes perpendicularly.

The increase in illumination in a room due to reflection from the walls is found by the following formula:

$$\text{Increase} = \frac{1}{1 - \text{Coefficient of reflection}}$$

VAUXHALL BRIDGE, LONDON, LIGHTED WITH SELF-INTENSIFYING GAS LAMPS.

Self-Intensified Gas Lighting

SCOTT-SNELL SYSTEM

By Charles W. Hastings.

In this article it is the intention of the author to treat of the arc system of Intensified Gas Lighting, but it will not be out of place to draw attention to the earliest efforts of the application of intensive burners for public lighting.

The Denayvouze burners were used in 1896 with a forced air supply, and in 1898 the Welsbach Company introduced a system of intensified gas supplied under pressure to their burners. During the Paris International Exhibition, held in 1900, the Paris Gas Company employed gas under pressure, using the Bandsept burners. In all some 4.676 mantles were in use and as many as ten mantles were grouped in one lamp. The duration of these mantles, working under very high pressure, was about forty-two days.

First mention of the Scott-Snell system appeared in the *Journal of Gas Lighting* in August, 1900, but it was not until the middle of 1901 that any particular attention was paid to the system. In that year Mr. C. Scott-Snell, the inventor, read a paper before the Gas Institute, and exhibited his Self Intensifying Gas Lamp.

All other systems that had been introduced involved a plant or equipment for the working of the compressor, causing considerable outlay and necessarily limiting the spheres of application. So far had this deterrent to the use of the various systems been recognized that Lecomte, a French gas engineer of great ability, invented a small water-injector, and fitted one to each separate lamp-post. Mr. Scott-Snell set himself to consider the selec-

tion of a force that he might avail himself of to operate any intensifying appliance; he very soon came to the conclusion that the utilization of waste heat was certainly obvious, and that in connection with gas lighting it possessed the advantage of costing nothing, and that neither shortness of water nor front would reduce its efficiency.

The utilization of such thermal forces was, however, beset with difficulties, and it did not appear to him that success would be achieved if they were harnessed to a motor for driving a compressor. Among the most prominent obstacles that presented themselves were the necessity for governing the speed and the pressure, the possibility of a dead center, troubles arising out of lubrication, vibration and minor obstacles, all of which assisted to make up a most difficult problem.

What was really needed was an appliance that would receive the gas, at its normal pressure, and deliver it at an increased pressure of eight inches of water or more.

(1) It must be operated by waste heat.
(2) It must require no lubrication.
(3) It must not have a dead center.
(4) No fly-wheel, slide valves, connecting rods, packed glands, or friction-producing appliances.
(5) It must be self-controlling.
(6) It must be low in price, simple in construction, and easily adjusted.

Mr. Scott-Snell could find no existent motor by which the ideal conditions set out could be achieved, but he reasoned that any apparatus using heat as a motive power was bound to include a displacer movement, and also that when gas at two different pressures was involved—a low inlet and a high outlet pressure—check valves were essential. His experience taught him that by the movements of a displacer within a vessel heated at one end and cooled at the other, gas or air could be drawn in at one check valve and ejected at the other, provided that some agency could be utilized to operate the displacer without involving the use of the prohibited appliance already referred to.

Such, then, was the groundwork upon which Scott-Snell set himself to build his Self-intensifying lamp; some will consider, and especially those who had the opportunity of seeing the lamps in operation, that the problem is very simple; but in these lamps a diaphragm, responsive to the variations of pressure, within the displacer chamber, had to be introduced; and the direct attachment of displacer to a diaphragm. The weight of the displacer being taken by a spring involves a curious and complicated condition of circumstances. It was, of course, assumed that heat being applied to the bottom of the vessel or container, expansion of the confined gas would take place and that the responsive diaphragm would lift the displacer until all the gas collected below the displacer and against the hot lower plate. Apparently, then, the displacer is retained at the top of its stroke until the expansive action of the gas is exhausted, the pressure falling and the displacer coming down again. Such an action, we are told, would be too slow for practical purposes, and in the application under review does not obtain.

The general applications are shown in the diagrams. The conditions under which the apparatus operates are as follows:

The vessel is charged with gas, one-half of which—the upper—is at a moderate temperature, say 80 degrees Fahr., the lower half being perhaps 500 degrees Fahr.; such a state, Mr. Scott-Snell says, may be quite consistent with perfect equilibrium of pressure throughout all the gas in its vessel. It will also be consistent with a flow of gas entering at the inlet valve, going across the chamber, proceeding to the outlet valve, and on to an incandescent burner or

elsewhere. But under such circumstances, the conditions of equilibrium are very unstable; and the slightest movement of the displacer—either up or down—would, it is obvious, lead to a transfer of cold gas to the hot side or heated gas to the cold side, and this would be followed instantly by contraction or expansion, inducing an immediate change of pressure in the chamber.

The accompanying diagrams will

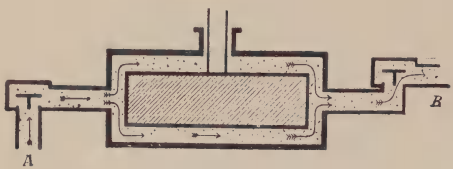


FIG. I.

FIG. 2.

FIG. 3.

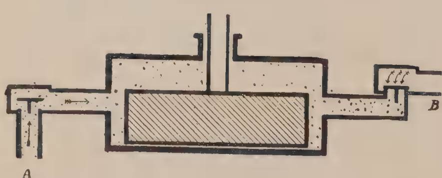


FIG. 4.

DIAGRAMS SHOWING ACTION OF "DISPLACER."

explain the action of the various parts of the displacer and diaphragm movements. Figure 1 shows a displacer chamber viewed when gas is passing through, but no heat applied; the displacer movement therefore produces no effect on the gas. Figure 2 shows the displacer at mid-stroke; Figures 3 and 4 illustrate the conditions which follow movement after heat is applied. In Figure 5 is shown essentially the conditions which obtain when a diaphragm is attached to the displacer rod and made responsive to the variations in pressure in the chamber. (In the present form no water jacketing is used.)

In order that the foregoing description may be more clearly understood, we will assume the displacer to be slightly yet quickly lifted. As a consequence a quantity of cold gas is added to the heated section and caused to expand; this expansion stops the inflow from the gas supply by reason of the rise of pressure, which acts upon and closes the inlet valve; it also causes a blow-out through the outlet valve, still more important in its effect on

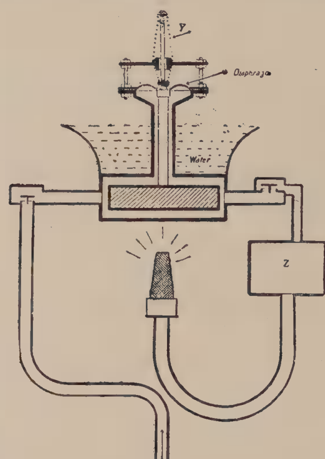


FIG. 5.—DISPLACER ACTING ON DIAPHRAGM.

the diaphragm, which by its movement still further lifts the displacer and drives more cold gas down to the hot side. This, therefore, owing to expansion, causes the initial lifting power to be reinforced, until a full stroke, or travel, is attained. As the gas, after passing the outlet-valve, goes to the pin-hole in the nipple, the rate of discharge to the atmosphere is comparatively limited, and pressure therefore increases rapidly in the intervening pipe and reservoir.

At the start of the upward motion of the displacer the spring to which it is attached counterbalanced gravity, but towards the end of the upward

stroke the spring ceases to exercise the counterbalancing effect to any great extent; in fact a point is reached where the loss of assistance from the spring exactly equals the lifting power on the diaphragm; this would, in practice, mean stoppage and be equivalent to the "dead center"; but the momentum of the displacer comes into play and causes the travel, or stroke, to extend beyond the critical counterbalancing position. The diaphragm was in a position, at half-stroke, to give the maximum lift, but its effect rapidly diminishes as it blows out, so that as the displacer lifts, not only does the counterbalancing effect of the spring become more feeble, but the effective area of the displacer, once in motion, will always travel beyond the point of equilibrium of the various forces, on account of its momentum. The reaction—when the momentum is exhausted—due to gravity, and the displacer naturally tends to fall back to such a point that the effective area of the diaphragm, multiplied by the pressure in the vessel, counterbalances the gravity effect, or such amount as the spring fails to sustain. When the displacer commences to fall it also begins to transfer a part of the heated gas below it to the cold section above it; thus starting condensation and rapidly reducing pressure until a partial vacuum is set up, which increases in intensity as the displacer falls. Another result is that the condition of partial vacuum set up by the depression of the displacer, is the causing of a rapid inflow of gas through the inlet-valve, which quickly overcomes the vacuum and relieves the diaphragm of atmospheric pressure.

The displacer on its downward limit is therefore subject to the following conditions:

There is no downward force on the diaphragm. The inflow of gas, at the pressure of the gas-main, tends to lift it; the spring being normally compressed also tends to lift the displacer back to mid-stroke. All forces have therefore become reversed in direction and a lifting power is in operation. The movements result in a reciprocation of the displacer at the rate of 120 cycles—up and down movements—per minute.

The peculiar action of the flexible diaphragm is illustrated in Fig. 6. The momentum causes the diaphragm, after blowing out in a spherical shape (1) to assume a conical shape (2), which is, of course, contrary to its condition of equilibrium under pressure. In the attempt to reassume a spherical shape it draws the displacer downwards (3). Pressure on the diaphragm therefore not only causes the displacer to be driven to the full extent of the up-stroke, but also part

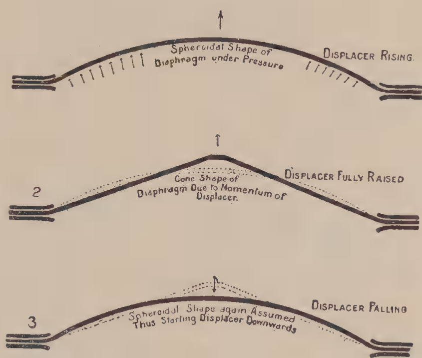


FIG. 6.—ACTION OF DIAPHRAGM.

of the way in the reverse direction. A spring is arranged under the bridge, carrying the displacer sustaining spring, in order to admit of an adjustable check to the momentum and to start a rapid downward action in the event of the diaphragm being so stretched or slacked that the cone shape is not reached when the displacer has attained its full stroke.

The apparatus, which we have described at such length, constitutes a reciprocating engine; not the least advantage, of such an engine, is that the rate of reciprocation is in accordance with the size of the gas-pipe. A lamp may have but one burner, the "engine" working at the rate of 120 cycles per minute, but if three nipples be used, as for a cluster of burners, the lamp will operate with greater rapidity,

delivering three times the volume of gas, and, consequently, it will have the waste heat from three burners to energize it.

The description given of displacer and diaphragm, which practically con-

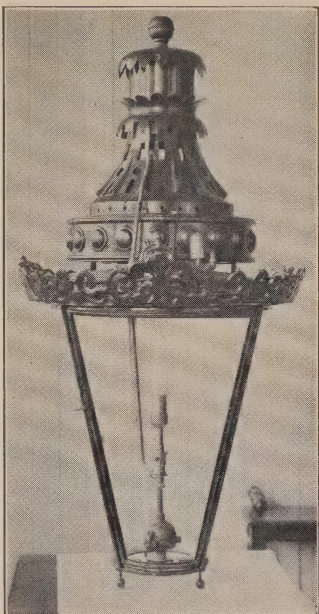


FIG. 7.—FORM OF LANTERN USED WITH SCOTT-SNELL LAMP.

stitutes the engines, are in a great measure the same as those used in the present "Improved Scott-Snell Lamp," other patents have been taken out, and many minor improvements made, but the principles are the same.

It will now be our pleasure to call attention to recent developments of self-intensified gas lighting by means of the Improved Scott-Snell lamp; a specially constructed lamp now in very general use is illustrated in Figure 7, and the air-cylinder in engine, Fig. 8. In the remarks we have made about the earlier lamps, it will be noticed that the "engine" was operated by the gas itself, but to-day the increased pressure is given to the air supply before its admission, first into a reservoir and then to the burner or burners.

In the Improved Scott-Snell lamps which have been recently set up in several parts of London, and particularly on the Vauxhall Bridge, a fine new bridge across the Thames, 80 feet wide with a 50-foot roadway and two 15 feet sidewalks. The bridge is lighted by sixteen lamps, which deliver automatically, and at no cost for power, air at a pressure of something over one pound to the square inch, and so intensifies combustion. The lamps are fitted with burners giving an illumination of 600 candle-power. The system in its earlier stages has been described at considerable length, but it will not be out of place to briefly describe the newer form. The action is due to the movement of a displacer vertically oscillating in a cylinder, Fig. 8, placed in the lamp, whereby

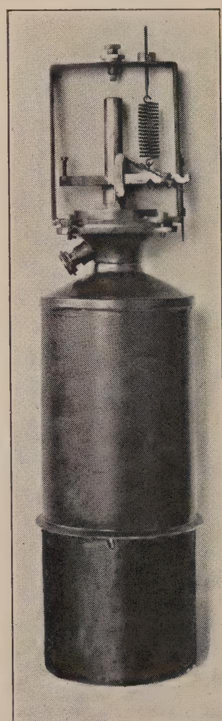


FIG. 8.—AIR CYLINDER AND ENGINE.

the arc end is heated whilst the other is freely exposed to the atmosphere and is comparatively cool. The displacer is suspended by a spring and its starting and continuous movement is automatic so long as the heat is main-

tained. This is effected by sealing the upper end or mouth of the cylinder by a leather diaphragm. The reasons for initial movement, we have fully described, they are the applications of scientific principles, which have been but little appreciated, applied in a particularly simple manner; in fact, an inlet-valve communicates with the atmosphere, an outlet-valve connects to a reservoir and thence to the burner, and in these are constituted the whole equipment of the self-intensifving gas lamp.

The capabilities of these lamps are really very considerable. They will deliver to one pound per square inch, at each stroke, and maintain a speed of 90 strokes per minute so long as the lamps are burning.

The question naturally will be asked, how is the high efficiency of the burner maintained? It is due not merely to the powerful air-jet supplied, but also to the manner of its application. The nipple delivers the compressed air in a central stream of very high velocity; around this rises an annular stream of gas of medium velocity, and outside of this again the indrawn Vortex flows at a still lower speed. "Vortex Rings"—the delight of cigar smokers—are formed in a most rigorous manner, and the intermixture of "intensified" air, coal gas and atmospheric air is thoroughly ensured.

In reference to the "economies" of self-intensifying gas lighting, we might draw attention to the same figures which were given in a paper entitled "Extracts from a Photometrist's Notebook," read by Mr. James Foreman before the North of England Gas Managers' Association last April The lamps referred to in the table are thus described:

(1) Scott-Snell lantern, just as sold, running at a pressure of 1-6 inches, consuming 17-5 cubic feet per hour, giving a mean hemispherical candle power of 560 candles, a duty of 32 candles per foot, and a cost of only 0.9375d. per 1,000 candle hours.

(2) Welsbach self-intensifying lamp, sold with a reflector as 600 candle power nominal, running at 2.8 inches pressure, gave a light varying from 615 candles, a mean hemispherical candle power of 452, a duty of 23.8 candles per foot, and a cost for 1,000 candle hours of 1.26d.

(3) Lucas Lamp of the 20 feet per hour pattern, run at 3 inches pressure,

SELF-INTENSIFYING GAS LAMPS REQUIRING NO AUXILIARY PRESSURE APPARATUS.

	Scott-Snell Lamp.	Welsbach Self-Intensifying Lamp with Reflector.	Lucas Lamp, 20 C. P. per Hour.
Barometer	29.5 inches	29.8 inches	29.7 inches
Thermometer (quality, 16 c. p.)	60 deg. Fahr.	59 deg. Fahr.	56 deg. Fahr.
Value	16.53 candles	16.08 candles.	16.1 candles
Calorific power value	616 B. T. U.	605 B. T. U.	620 B. T. U.
Pressure in inches of water	1.6	2.8	3.0
Corrected gas consumption in cubic ft. per hr.	17.5	19.0	23.5
Candle-power horizontal	718.0	615.0	715.0
10 deg. S.	647.0	575.0	750.0
20 deg. S.	678.0	543.0	660.0
30 deg. S.	612.0	473.0	548.0
40 deg. S.	538.0	420.0	505.0
50 deg. S.	497.0	360.0	416.0
60 deg. S.	397.0	280.0	256.0
70 deg. S.	335.0	210.0	104.0
80 deg. S.	0.0	190.0	36.5
90 deg. S.	0.0	175.0	28.0
Mean hemispherical candle-power	560.0	457.0	522.30
Candles per c. ft., a mean hemispherical candle-power	37.0	23.8	22.31
Cost of gas only for 1,000 hours; gas at 2s. 6d. per 1,000 c. ft.	0.9375d.	1.26d.	1.35d.

gave a mean hemispherical candle power of 522.3, a duty of 22.21 candles per foot, and a cost of 1.35d. for 1,000 candle hours.

It will be seen that the Scott-Snell lamps are essentially dependent upon their own mechanism, without aid from abnormal supply pressures to obtain the above results. It is also differentiated from all others as supplying moving parts, being, in fact, an engine, but without any drawback on that score. The system has been put forward in this country (Great Britain) to fight the battle for gas as against electricity, and an extensive installation has been set up in one of London's most important thoroughfares—Oxford street. The relative figures came out distinctly in favor of the Scott-Snell lamps. We have already mentioned that these lamps have been chosen for the illumination of the new Vauxhall bridge. These are two instances which are being closely watched by all illuminating engineers. The results are eminently satisfactory, although the author is not able, at present, to include precise figures. The Oxford street district, which is under the control of the Lighting Committee of the Marylebone Borough Council, will be lighted, when complete, by about 200 lamps; the tenders for this work are interesting and the figures are as follows:

Electricity Installation, £3.440 ($16.512).

Gas Installation, Improved Scott-Snell Lamps, £1.566 ($7,516.60).

Lighting 2c. Electricity, £1.785 ($8,572.80).

Lighting 2c. Gas 1.681 ($8,068.80).

Many other installations have been carried out in the provinces. The Improved Scott-Snell Lamp is explicated by the licensees and manufacturers, Messrs. D. Anderson and Company, Ltd., of Farrington Road, London, E. C. (England.)

It will be interesting to conclude this article with a few remarks made to us by Mr. Scott-Snell; he is at the present time engaged upon an apparatus for "setting up" gas pressure for internal use where a large number of lights are required, of comparatively small size, the Self-Intensifying Lamp being designed for use where larger units of light are required. We cannot, at present, give full details, but may in some future article describe and illustrate the new apparatus which is unique, inasmuch as the *gas is increased in pressure without a single mechanical moving part.* Mr. Scott-Snell is also perfecting in his laboratory some important advances in low pressure, gas supply to ordinary purposes. He is of opinion that gas lighting contains potentialities which will when fully investigated place gas, even in countries where electricity apparently holds almost undisputed sway, in a premier position as a dividend-earning agent. The advances already made are fairly ratifying to "the man in the Street," but to the scientific, analytical mind the progress, he thinks is all too slow. In these days competition is very keen, and since the flame arc lamp is so much in vogue, it will give to gas improvements a powerful impetus; gas will be more scientifically used,

Mr. Scott-Snell speaks with authority; he was associated with the earliest electric lighting undertakings in London, and had charge of the Jablochkoff electric lighting installation on the Thames Embankment—the first thoroughfare in London, if not in Great Britain, lit by electricity. He was also one of the earliest practical men connected with the exploitation of the Welsbach mantle and in the service of Messrs. Woodhouse & Rawson he made numerous experiments in burners, and devised, what has proved to be the basis of all subsequent burners—a small body and a large head. For a period of more than a quarter of a century, Mr. Scott-Snell has given his best service, research and experiment to the perfection of economic and high photometric gas illumination as a close perusal of this article will clearly enunciate.

The Electrolytic and Metallic Arc

By Isador Ladoff.

A glance at the tables given below will convince us that:

I. The highest spherical candle-power is obtained by the flaming arc of Bremer. (This is due chiefly to the luminescence of the metallic salts, with which the Bremer carbons are saturated. This arc is called a flaming arc in contradistinction to the ordinary carbon-crater arc. The color of the arc, the unsteadiness and the slagging of the carbons make the Bremer lamp obnoxious.)

II. The loss of energy in the shape of heat is the greatest in the alcohol lamp and petroleum.

III. The loss of energy in the shape of heat is the smallest in the Bremer and ordinary carbon arc.

IV. The cost per hour is the lowest in the petroleum, and next in the Welsbach lamp.

V. The cost per candle-power hour is in the last analysis the lowest in the carbon arc.

All these data force upon us the conclusion, that the carbon arc is so far the most economical source of artificial light. And yet, even there in the carbon ars as a source of light is a surprising loss of energy in the shape of heat as the following simple calculation will demonstrate.

In our ordinary source of light 95% of the energy spent is consumed in the production of radiation, whose wave-length is greater than 0.81, *i. e.*, of radiation that does not affect our eyes. These 95% may be considered as totally wasted from the point of view of production of light.

The resin torch used by the savage gave an efficiency of about 3% to 4%, while the carbon arc furnishes about twice as much only.

A steam engine, necessary for the

Table No. 1.

The Metallic Arc.

COMPARATIVE EFFICIENCY OF VARIOUS SOURCES OF ARTIFICIAL LIGHT.

	Watt per C.P. Used.	Degree of Efficiency.
Petroleum	$0.113 \quad 10^{-6}$	$0.029 \quad 10^{-2}$
Alcohol	$0.00092 \quad 10^{-6}$	$0.0068 \quad 10^{-2}$
Gas (Welsbach light)	$0.00183 \quad 10^{-6}$	$0.018 \quad 10^{-2}$
Carbon filaments	$0.083 \quad 10^{-6}$	$0.2 \quad 10^{-2}$ to $0.48 \quad 10^{-2}$
Osmium light	$0.077 \quad 10^{-6}$	$0.85 \quad 10^{-2}$
Nernst filament	$0.127 \quad 10^{-6}$	$0.3 \quad 10^{-2}$ to $0.34 \quad 10^{-2}$
Carbon arc	0.0215 to $0.0047 \quad 10^{-6}$	

AT THE PRICE OF 10 CENTS PER K. W. H.

	Intensity of Light. Normal Horz. C.P.	Normal Spher. C.P.	Consumption per Hour.	Heat evolved per Hour.	Quotient of Heat. N.C.P. Sph.	Cost per Hour.	Cost per Hour in Pfennigs.
Petroleum	14.8	13.2	43.6	480	36.49	1.09	0.083
Alcohol	65.3	42.9	129 grm.	6.98	16.3	3.78	0.088
Gas (Welsbach light)	73.8	52.3	112.3 l.	573	11.0	1.39	0.027
Carbon filament	43.8	34.6	104 w.	89.8	2.6	4.16	0.12
	18.3	12.8	59 w.	57.0	3.99	2.36	0.18
Osmium light	42.3	31.4	48.7 w.	42.1	1.34	1.95	0.062
Nernst filament	184.0	113.0	213 w.	184	1.63	8.52	0.075
Carbon arc	....	400.0	440 w.	380	0.95	17.6	0.0094
Bremer arc	....	1880.0	440 w.	380	0.202	17.6	0.0094

"Neuerungen in der Beleuchtungs-Technik." *Zeit. Ingen.*, 1904, 676.

production of electric power, has a maximum efficiency of 10%. The efficiency of the dynamo electric machine being 90%, we get only 9% energy. Assuming a loss of 10% in the conductors, etc., there remains to be expended in the arc lamp energy equal to 0.08% of the original energy. However, of this energy expended in the lamp 90% is wasted in the shape of heat and only the remaining 10% alone are consumed in the production of light proper. The final efficiency of our most efficient source of light—of the carbon arc—is 0.0081 or less than 1% of the total energy expended.

Obviously there is room for improvement in the field of artificial light production.

We may never attain the efficiency of light emission accomplished by the glow-worm or luminous insects, producing only ether vibrations included between 0.81 and 0.360.

But the time seems to be ripe for an attempt to utilize the luminescence of metals and oxides of metals. The attempt to combine the principles of incandescence of carbon with the luminescence of certain metallic oxides resulted in the so-called flaming arcs similar to Bremer's. These impregnated carbons are far superior to the untreated carbon arc as far as efficiency and distribution of light is concerned. But the life of the pencils is rather short. Slag forms during combustion and requires a great deal of care.

The Luminous Arc Formed by Impregnated Carbons.

By introduction into carbon electrodes of substances having a high light radiating power (electrolytes) such as salts of the calcium group of elements, the carbon arc itself is rendered highly luminous and becomes the principal source of light, instead of the heated end of the positive carbon (crater), as in the case of the ordinary arc lamp. The hot gases generated by volatilization of the salts in the carbon furnish a path of less resistance than the air for the passage of the current and this permits the electrodes being drawn much farther apart (higher drop of voltage across the arc), producing an arc of 1½" to 2½" long. The light thus produced is, with the calcium salts, of a golden tint, hardly distinguishable from the color of light of an ordinary flame and incandescent electric lamps. This yellow color of light is for the purpose of exterior illumination, a point decidedly in its favor.

In efficiency as light producer, the luminous arc is revolutionary.

The measurements made by the Electric Testing Laboratories with a luminous lamp, producing the yellow light, and with an enclosed arc gave the following results:

	Arc. Luminous.	Arc. Enclosed.
Mean amperes	8	5.1
Mean volts at arc	45	81
Mean watts at arc	360	413
Mean spherical C.P.	1,020	232
Mean lower spherical C.P.	1,560	260
Watts per mean spherical C.P.	0.353	1.78
Watts per mean horizontal C.P.	0.265	1.59

In actual light production the luminous arc is, therefore, practically five times as efficient as the enclosed arc. The lamps tested were run on direct current, and were fitted with opaline globes of practically equal density.

A comparison of the two curves from the tests alone referred to, is shown in Figure 1. Both curves refer to vertical planes, one passing through the carbons and the other at right angles thereto. The dotted curve of small area represents the light flux of an enclosed arc. (Mr. E. L. Elliott's paper; The Illuminating Eng., V. I., pp. 90-91.)

It has been impossible in practice to increase the proportions of the additions with which the luminous arc carbons are impregnated above 6%, since above this limit the light is no longer steady.

Mr. Mehlke in "Zeitschrift für

Beleuchtungwesen" March 10, claims the possibility of increasing the impregnating additions with a resulting higher efficiency, in the carbons of direct current luminous carbon arcs impregnated with different materials. For the positive carbon, metals are suitable which form bases, like calcium, magnesium, barium, while the negative carbon should be impregnated with metals which form acids, like Tungsten, Chromium; suitable additions for the positive carbon are fluorspar and magnesium, and for the negative carbon Tungstaic acid and Chromium fluoride.

The short life of the impregnated

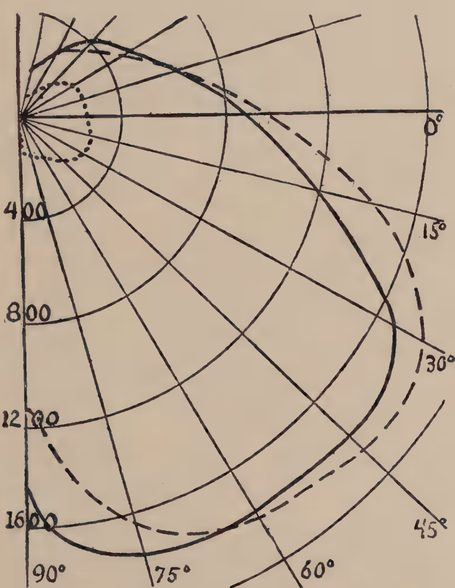


FIG. I.—DISTRIBUTION CURVES OF INCLOSED AND FLAMING ARC LAMPS.

carbon, the slagging formation and the comparatively poor distribution of light are the drawbacks of the impregnated carbon. Only 16% of their total illumination is given off in the range between 0 and 20 degrees below the horizontal, that is, within the useful range for street illumination.

The curves shown in Fig. 2 give the comparative distribution of light from various sources of illumination, formed part of a paper printed in a German gas journal, the author being Prof. H. Drehschmidt, of Berlin. The measurements were made by means of an arrangement due to Schmidt and Haensch, employing a mirror attached to a jointed parallelogram, whereby the light at any angle is directed horizontally for photometric measurement. For comparative purposes the horizontal intensity is 100 Hefners for each source.

Of the several curves *W* is that of the ordinary Welsbach lamp; *O* that of the Osmium lamp; *N* that of the Nernst lamp; *A* that of the electric arc., *i*, that of the incandescent carbon filament lamp; *F*, that of the electric flaming arc and *G* that of an inverted gas burner.

Commenting on these curves, Prof. Drehschmidt says: That of the sources, *i*, *O* and *N* (with vertical magnesium rod), send about as much light upwards as downwards. The electric flaming arc, *F*, though it sends all its light downwards, gives very poor lateral illumination and strongly illuminates only a limited region below the lamp. The electric arc *A*, is best at about 30 degrees below the horizontal, but is pretty poor immediately beneath.

The most scientific worker in the field of impregnated carbons is undoubtedly Blondel. Here are a few data from his contribution to the transactions of the Int. El. Congress at St. Louis, 1904, V. VII, Section F.

The substances added to the carbons are phosphate of lime (10%), also oxides, chlorides and fluorides of lime, and magnesium, aluminate of lime. Blondel mineralizes the core and envelops it with a cylinder of pure carbon 1/5 to 1/7 thickness. Together with Bremer, he uses preferably fluoride of calcium. Blondel also adds various salts as regulators. He considers a mineralization of 20-30% and prefers to concentrate the mineralization in the anode, which he places below.

L. Lindeman in the Annalem d. Physic Bd. XIX, Heft 4 (Licht-Electricke Photometric) claims that he im-

pregnated electrodes as the positive has to be placed below in order to get a quick arc, just as Blondel.

According to W. H. Patchel (London *Times* Engineering Supplement), the following figures made a comparison between different types of lamp for the same candle-power per hour with current 4.06 cents a unit. Oriflame (350 watts), 0.812 cents; Weinert (350 watts), 1.12 cents; Excello (470 watts), 1.16 cents; Santoni (420 watts), 1.43 cents; 1,000 watts carbon lamp, 2.03 cents; open arc (500 watts), 3.04 cents; Evelina arc (500 watts), 4.16 cents; enclosed midget arc (250 watts), 6.07 cents.

authority claims that the relative intensities of two primary spectra of a mixture of gases depend on the relative atomic weight of the compound gases. Other things being equal, in the spectrum of a mixture of gases, the spectrum of the gases of greater atomic weight will be higher.

In view of these facts and observations a few theoretical considerations may appear welcome.

It seems to be obvious, that we have to do in impregnated carbon arc, with photo-electric effects connected with the absorption of ultra violet rays of the spectrum. Indeed, according to I. I. Thomson (conductivity of elec-

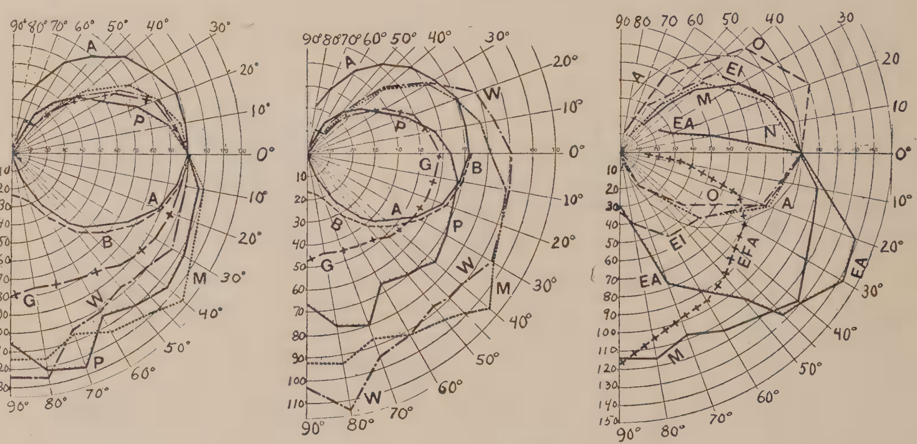


FIG. 2.—CURVES OF DISTRIBUTION OF VARIOUS LIGHT-SOURCES.

The effect of addition to the carbon electrodes of volatile salts consists in the lengthening of the arc, following a corresponding drop of potential, not only at the terminals, but in the gases composing the arc, whose conductivity is increased. According to L. F. Tufts (*Phys. Review,* C. XXII, 4 p. 273), the luminosity of a flame varies in the same sense as the conductivity of the gases composing it. According to F. S. Nutting (Bull. of Board of Standards, VI, 1), salts introduced into the arc seem to reduce its temperature (Ranner, for instance, found a difference of 170 degrees C. between the temperature of an arc between cored and solid pencils). The same

tricity through gases, Cambridge *Review Press,* 1903), the elements having the highest atomic volume: Caesium, Rubidium, Potassium, Sodium, Nitrogen, Lithium, are the most electro-positive. The conductivity imparted by these metals or rather by the salts of these bodies, under the same conditions as to temperature, potential difference and concentration, is directly proportional to their atomic weight and atomic volume sequence. The Caesium salts imparts to the flame the highest conductivity, then follow the salts of Rubidium, Potassium, Sodium, Lithium and Hydrogen. Here follows a table of conductivity of these bodies prepared by H. D. Wilson:

TABLE OF THE CONDUCTIVITY OF THE SALTS OF RUBIDIUM, POTOSSIUM, SODIUM, LITHIUM AND HYDROGEN PREPARED BY H. J. WILSON.

	Chlorides.			Nitrates.		
P. D.	5.60	0.795	0.237	5.60	0.795	0.237
		Current.			Current.	
Cresium	12.3	60.5	22.2	30.3	11.5	3.6
Rubidium	41.4	26.4	11.3	21.3	82.4	25.9
Potossium	21.0	13.4	5.75	68.4	29.3	9.35
Sodium	3.49	2.45	1.15	3.88	2.67	1.32
Lithium	1.29	0.57	0.41	1.47	0.99	0.53
Hydrogen	0.75	....	0.27	....	....	....

Elstein and Sertel found, that the more electric positive metals lose negative charges even when exposed to ordinary daylight (absorbing ultra violet rays). According to these investigations, the metals are to be arranged in the order of the contact series of volts, in order to express their respective sensitivity to photo-electric effects. The effect of absorption of ultra violet rays are expressed in the degree of leakage of negative electricity from surfaces of Sodium, Potassium and Rubidium in white light.

Rate of Leakage of Negative Electricity. Sodium, 21.0; Potassium, 53.1; Rubidium, 537.0. The sunlight is comparatively poor in ultra violet rays. Filtering through the atmosphere, the light of the sun gives up considerable of its ultra violet rays.

The arc light being rich in ultra violet rays naturally produces a more potent photo-electric effect on electro-positive bodies.

All the salts of the same metal impart the same conductivity to the flame according to Arrhenius. According to the same authority, all the salts in the flame are converted into hydroxides, so that whatever salts are used, the metal in the flame always occurs in the same salts. This does not coincide with our experience, which shows that for instance flames of Potassium is twice as effective as nitrate of Sodium. The salts steady the arc by enriching it with negative ions at a comparatively low temperature.

The voltaic arc is a portion of the electric circuit and has all the properties of other parts of the electric circuit. Things go on exactly as if the electrodes were united by a solid body of small cross section. The light emitted by the body is due to the heating of a resistant body interposed in a circuit.

The true nature of the arc appears when we study it in a vacuum.

The following data shows the behavior of the various electrodes in a vacuum, when graphite was used as an anode (according to Child).

Metal.	Drop in Potential.	Melting Point in Everett's C.G.S. System of Units.
Platinum	No arc could	1775 degrees
Iron	be maintained,	1600 "
Nickel	when using	1450 "
Copper	these metals	1054 "
Silver	as cathodes.	954 "
Aluminum	19	600 "
Antimony	8	432 "
Zinc	9	412 "
Lead	8	326 "
Cadmium	7	315 "
Bismuth	6	260 "
Tin	8	230 "

The current was 10 amperes, the e. m. f. of the circuit was 100 volts, and the distance between the electrodes 2 mm. In all cases the total fall of potential about the anode as approximately six volts more than at the cathode. To this list may be added sodium, potassium and mercury. Dr. Weintraub gives the sum of the drops in potential at the cathode and anode for these to be 8.8 and 7.5 respectively, while their melting points are 96, 02 and 40. In general, *the higher the melting point, the greater the drop in potential at the cathode* necessary to maintain the arc. The principal exception to this rule was in the case of tin, but the thermal conductivity of tin is greater than that of other metals.

and it is quite probable that on this account it requires a greater development of energy to keep it in a melted condition. If this is correct, *the drop in potential at the cathode is a function of both: of the melting point and of the thermal conductivity of the metal.*

Measurements of the fall of potential with these metals were made as the pressure of the gas was increased by drawing air into the tube. It was found that with the higher pressure all of these metals could be used as a cathode. It was also found that in all cases the fall in potential about the arc was increased as the pressure of the gas was increased. The series of readings for these potential differences when lead was used as the cathode is given in the table below. The readings taken with the other metals were quite similar to this one.

Pressure of Gas.	Potential Difference About the Arc.
0.4	14
2	15
6	16
20	17
60	19
200	22
400	30
550	30
730	32

(C. D. Child, Phys. R., V. XX., 6, 373.)

It seems obvious that the process of oxidization plays an important part in the arc, as I noticed myself long ago and will explain more fully later. The melting point seems to be of great importance.

We can see why chemical combination should tend to diminish the potential difference between the terminals of the arc. The heat evolved by the oxidization of the terminals would tend to maintain them at incandescence so that the whole of the energy required for this purpose would no longer have to be supplied by the electric field. This is the reason why no arc can be maintained in a vacuum between metals having a melting point higher than that of aluminum and consequently a correspondingly high point of vaporization. The distinction between an electric spark and the discharge from a point on one hand and an electric arc is in the relation between the pressure and the current. In the case of the spark, the current is only a fraction of a milliampere. In the case of the arc the pressure is very much smaller than in the spark, while the current is very much larger. It takes several hundred volts to discharge a spark. The temperature generated by a high pressure is correspondingly high and the spectrum produced of lesser complexity, than that of low pressure. The connection between the difference of potentials between metallic electrodes, the length of the arc and the current may be expressed by Froelichs' formula:

$$V = M \text{ plus } NE$$

where M and N are constants, *i. e.*, independent of L.

M is larger the higher the point of vaporization of the metal. Langs data arc:

C.	Pt.	Fe.	Ni.	Cu.
35	27.4	25	26.18	23.86
Ag.	Zn.	Cd.	Hg.	
15.23	19.80	10.26	12.8	

According to Dr. Weintraub (*Phil. Mag.*), in order that an arc should start between two mercury electrodes, placed inside a highly evacuated space, and connected to a source of moderate voltage (magnitude of a few hundred volts), the cathode must first be rendered active, and we will interpret this in the light of the ionic theory by assuming that *an ionization process must be started at the surface of the cathode in order to allow the passage of the arc through the metallic vapors.* In contradistinction to the ordinary carbon arc the voltage varies in the same sense as the current. In the arc-stream we must distinguish between the two different kinds of mercury vapor, the ionised conductive one and the ordinary mercury vapor produced by superfluous vaporization of the mercury. This later part of the mercury vapor hinders the motion of the ionised particles, and by doing this, increases the resistance of the arc path.

(To be continued.)

THE ILLUMINATING ENGINEER

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PROGRESS OF THE REVOLUTION

That the entire lighting industry, so far as methods of producing light are concerned, is in the incipient stages of revolution, there can be no longer a reasonable doubt. Progress generally advances by stages or epochs, and the coming year seems likely to mark an epoch in the history of illumination. After more than a decade of running on a "dead level" there has suddenly arisen a world-wide interest in the entire field of illumination. Prominent scientists and inventors have been devoting their time to devising more economical methods of producing light, and engineers, architects and users have awakened to the importance of the part that artificial light plays in modern civilization. The recognition of Illuminatng Engineering as a distinct specialty dates from the present year.

In our review of the technical press in this issue, we present a complete *résumé* of the recent improvements in the production of light by electricity. Still further summarizing this *résumé* it may be stated that these improvements follow two different lines. First, the use of gas as the luminous body, in place of a solid. The mercury arc, the vacuum tube, and the flaming arc, are the net results of the work in this line to date; and they all represent such advantages, either in economy, or quality, or both, as to justify being characterized as revolutionary. The flaming, or luminous arc, is five or six times as efficient as the type of arc lamp now in general use, and is probably the most efficient of all artificial light thus far discovered, while the mercury arc and vacuum tube systems are highly efficient, besides having so low an intrinsic brilliancy as to render them revolutionary in the softness and diffusion of the illumination produced.

The second line research has been directed toward utilizing the well-known advantages of the group of elements known in science as the rare, or infusible, metals in place of carbon as the radiant. The tantalum lamp was the first practical result of this work, and since its advent, numerous other lamps utilizing these elements have been more or less fully demonstrated. In view of the complete revolution effected in gas lighting by use of these rare elements in the Welsbach mantle, and the knowledge of their properties thereby obtained, and further considering the variety of substances and methods of forming them into lamp filaments that have been developed within the past year, it seems remarkable that these improvements have been so long delayed. Theoretically, tungsten offers the greatest advantages as an incandescing material, and tests which have been made indicate that the theoretical advantage will be maintained in practise. The "watt lamp," i. e., a lamp running at an efficiency of one watt per (rated) candle, is at hand. As compared with the 3½ watt carbon filament lamp, the one watt lamp is certainly revolutionary.

Aside from the gain in economy, the advent of this new light-source presents a number of aspects that furnish fruitful themes for speculation. Perhaps the most striking of these is the

fact, that in one of the most important features of illumination the two lines of development diverge very radically. While the development of incandescent vapor lighting reduces glare to such an extent as to approach diffused daylight, the rare element incandescent lamps owe their advantage in economy entirely to an increase in "intrinsic brilliancy," which is the technical term for glare. The diffusion of the light of these lamps by some accessory, such as frosted or prismatic globes, will be an absolute necessity. Diffusion by an accessory in all cases means a certain loss of light, but as in the case of the incandescent gas burner, the gain in economy in this case is so great that a portion can be sacrificed to diffusion, and still leave a large net gain.

In the matter of diffusion by such means, a very curious fact has been brought out by the Tantalum lamp. While frosting the bulb of a carbon filament lamp decreases its useful life 40%, it appears to actually increase the life of a tantalum lamp. Whether the same results will follow in the case of the other metallic filament lamps remains to be seen, but the chances are that they will. The new lamps should regularly be put out in frosted bulbs, providing their life is not shortened thereby.

Lamps of this class thus far produced require to be run in a vertical position, as the filament softens when lighted. This peculiarity, however, is of much less importance than might at first seem. There is really very little need for a lamp to be used in any other position. It is a perfectly simple matter to direct the rays of the light from any given source in any given direction, without changing the position of the source. The use of the ordinary carbon filament lamp is an inclined position is in most cases an absurdity. These lamps are often used pointed at an angle from the vertical, with the obvious inference that their light will be thrown out in the direction in which they point. When it is remembered that such lamps give less than one-half their maximum intensity in the direction in which they point, unless provided with some sort of reflector, the absurdity of the practise will be apparent.

One of the peculiar difficulties in making these new lamps has been the low resistance of the filament, thus making it difficult or impossible to construct small units for the voltages in present use. This fact, however, may have an important bearing in the extension of electric light. Lamps may be readily made to run at ¼ the voltage now most generally used—110—and for special purposes on very much lower voltages, without serious diminution of their efficiency. This should go far towards solving the problem of the very small isolated plant, such for example, as would be required for lighting a country house. The perfection of the gasolene engine as an economical source of power requiring little attention, and with improvements in storage batteries, the luxury of electric light should be brought within the reach of the average householder. A storage battery is absolutely essential in such cases, in order that the current may be available for light at all hours of the day; and a battery sufficient to supply this minimum current at a voltage as low as 20 or 25 would be comparatively inexpensive. Kerosene burnt in a combustion engine, and thus converted into electrical energy, and this in turn converted into light by these new lamps, would be much more economical, to say nothing of the greater elegance and convenience, than could be obtained by burning the oil in the old-fashioned lamp.

The future status of the arc lamp is another point suggested by these improvements. While the flaming arc still retains for this type of lamp its position at the head of the list in point of economy, the ultimate field of its usefulness has yet to be determined. Its high total light-power is,

for most purposes, a distinct disadvantage. One conclusion, however, may be readily reached, and that is that the inclosed arc, which has held the field for a number of years, must eventually be entirely displaced. With an efficiency of one watt per candle to the credit of the incandescent lamp, together with its advantage in requiring far less care, and especially in view of the fact that it can now be produced in much higher units, leaves the inclosed arc without a single point of superiority for either interior or exterior illumination.

In the domain of gas lighting progress is being made of such a character as to insure a probable maintenance of its present position in the lighting field. Improved methods of making incandescent mantles are being perfected, and the possibility of increasing the efficiency by increased pressure is being taken advantage of. What appears to be a simple and practical device for securing this last advantage is described in another section of this issue. Reduction in the cost of producing gas is also imminent. Suggestion has been made by prominent engineers in England to produce the gas at the coalfields and pipe it under pressure to the distributing mains. Why should this not be done in this country, as well as in England? Natural gas has been so conveyed in this country for years past.

This outlook over the lighting field would be incomplete if we failed to mention the valuable, if less striking improvements that have been made in the design and manufacture of accessories for distributing and diffusing light. The application of optical principles in the construction of prismatic diffusing globes and reflectors has been carried on for the past ten years with great care and intelligence, and the results obtained have fully justified the labor and expense incurred. Globes and reflectors thus constructed are the scientific compliments of the higher light intensities produced in the more economical forms of light-sources, and are deserving of no less credit.

ILLUMINATING ENGINEERING AS A DEPARTMENT OF MUNICIPAL GOVERNMENT

It is a generally recognized theory in municipal government that, for the various departments of administration, executive officers should be provided who are especially qualified in the particular line of activities involved. In a number of these departments the nature of the work demands engineering skill—as in the care of parks, streets and highways, waterworks, etc.

Among the most important of the utilities managed by a city is its public lighting. It would seem, therefore, that the office of Municipal Illuminating Engineer is as obvious and necessary as that of City Surveyor or Waterworks Engineer.

The agitation of municipal ownership of lighting plants is probably due as much to dissatisfaction with the quality of illumination afforded by the average system, as with the mere matter of cost to the public. Since, as we have frequently pointed out before, neither public nor private consumers pay for light as measured by illumination received, but for the luminant, or means of producing light, consumed, it is not at all strange that they should be disappointed by reason of the discrepancy between what they think they are paying for and what they actually get. Recent investigations in various parts of the country all bring out the same conditions more or less prominently, namely, that neither the corporations furnishing the illumination, nor the public officials responsible for its use, have any adequate knowledge of the scientific and economical principles involved. In the few cases in which expert testimony on illumination has been introduced, the city authorities have admitted that they were unable to understand the reports on account of the "technical terms used," and that little or nothing

has been gained, except a reduction in price.

The following instance will illustrate this point. Some months ago the question of renewing the contract for lighting the streets came up before the Councils of a large southern city. In reporting their action in the matter the local paper commented as follows:

"That the city's lighting contract with the ——— Electric Company is subject to a number of contradictions, and that the '600 standard candle-power arc lights' may mean almost anything, was forcibly brought to the attention of the members yesterday when a report from Mr. ———, which had been made at the request of the Director of Public Works, was presented. The report of the expert is in detail, but the use of technical terms and a diagram made it difficult for the aldermen to clearly follow it. The report was turned over to Alderman ——— at his request, as he stated, that he wished to study it and make some observations on his own account before the next meeting."

It thus appears that there was no officer or employee connected with the city government capable of giving an authoritative opinion on this important question, although, according to the report of the expert, by a simple change of globes, "$10,000 worth of additional effective light could be secured." If this much could be saved by so simple an operation, how much could be saved in money, to say nothing of improvement in quality, if the entire lighting system were put in charge of a competent illuminating engineer?

Probably the most thorough investigation that has taken place in any city in regard to public lighting, both by gas and electricity, is the one that was conducted several months ago by the State Gas and Electricity Commission for the city of Syracuse. Expert testimony was produced on both sides, and the matter was apparently sifted to the bottom. One of the results of this investigation is a judgment by the Commission reducing the price which the local company may charge for gas and electric current; but a result of greater local importance, and one likely to have a far-reaching influence, is likely to follow, according to the Syracuse *Herald;* which says:

The creation of a municipal bureau of inspection and complaint of lighting will be one of the results of the decision of the State commissions of gas and electricity handed down yesterday. This will be fully as important as any other result of the Syracuse investigation. The public learned a lesson on that investigation, and the feeling at the City Hall is that, whether the lighting company's intentions be good or not, no more chance should be taken in the future on the lighting question.

If such a bureau of inspection and complaint can be run at $3,000 a year, the saving in this year's street lighting fund alone, from the results of the investigation, would support it for six years.

The investigation disclosed the fact that frequently the lighting company delivered unsatisfactory gas and that the public had numerous other grievances besides the price. The commission has now undertaken to remedy this by establishing a standard of gas in Syracuse. It is considered, however, that this standard is likely to be ineffective unless backed up by an official bureau having authority to determine and enforce.

The idea of the bureau is to have daily tests of gas made so as to insure that the gas is up to the 18-candle-power and minimum 1-inch pressure required by the commission and that the gas does not contain more than the amount of sulphur, ammonia and sulphuretted hydrogen allowed by the commission. Only by keeping it up to this standard will the public be satisfied and the decision be effective as to gas.

Quality was the nub of the gas question. The public did not seem to complain of the rate of $1 a thousand for gas, which was lower than in most other cities, provided they got 1,000 cubic feet of it at the right pressure and could make a satisfactory illumination with what they got. The lighting company's shortcoming on gas was on this point.

There are numerous other duties which will devolve upon this bureau. It can handle the matter of street lamp inspection and see that the policemen properly report all lamps out or in trouble, not relying on the company to do so itself.

It can take care of complaints of defective wiring and lighting, improper service in any respect from the lighting company, and in general see that the lighting laws and the order of the commission are enforced. Consumers with grievances should find such a bureau, if it is properly managed, a source of great profit.

There are a number of State laws concerning gas service, when it shall be given, when meters should be inspected and how, and various other phases of the lighting

question which should be enforced by such a commission.

The amount suggested for running a department for one year—$3,000—is, of course, ridiculously small in comparison with the amounts paid for other services of far less importance, both from the money point of view and that of public convenience; but all new departments must start in a conservative way, so far as expense is concerned.

Public buildings, including school houses, are as a rule the poorest lighted of any to be found in a municipality; and it is a generally admitted fact that street illumination in this country has many and serious faults.

The office of City Illuminating Engineer is one which should be at once established by all municipalities, and the department under this title be supported by as fair and liberal appropriations as those granted to any other department of equal importance.

While the department of Illuminating Engineering has not yet been recognized by name, it has been established in fact by the National Government, the work at present being in charge of Mr. J. E. Woodwell, whose valuable descriptions of the installations in some of the largest Federal buildings have recently appeared in our columns. Mr. Woodwell is ably assisted by Mr. P. L. Dougherty. These two illuminating engineers are officially known as "Inspectors of Lighting Plants." Some idea of the value of their services can be found from the fact that in the lighting of the Chicago Post Office Building alone, a saving of $40,000 per year has been made over the amount required by the lighting plans as originally laid out; electric current being purchased at a cost of 5c. per k. w. h.

THE CARTOON AS A TECHNICAL ILLUSTRATION

Technical papers are usually considered to be consecrated exclusively to the exposition of scientific truths, and hence the only illustrations admissible are those giving mechanical details of apparatus and machinery, or mathematical curves and diagrams. Wit and humor, with its counterpart, the cartoon, have traditionally no part in scientific discussion.

Is this tradition founded absolutely upon the merits of the case? The contemplation of scientific facts does not naturally develop the "saving grace of humor"; nevertheless, there are some notable cases in which the most recondite scientific research has not been able to suppress this valuable means of grace. Tyndall and Huxley did more to popularize science than all other writers of their time combined, and not the least of their power was in their keen sense of humor, as displayed in their writings. Among writers on illuminating engineering problems at the present time, Mr. A. P. Trotter, an Englishman, possesses a keen and ready wit.

The idea of using the cartoon to impress technical facts upon a popular audience has been attempted by Mr. Willcox, in his paper read before the Ohio Electric Light Association, and which we reprint in another column. We will leave it to our readers to judge whether this innovation is compatible with the supposed dignity of such papers, and whether such illustrations actually tend to impress the points made in the paper upon the mind of the reader. Whatever the decision may be, it will be generally admitted that any radical departure from an established custom must be made with indisputable skill, otherwise the whole matter at once becomes a mere burlesque. If the matter has a humorous side, it must be brought out in a spontaneous manner; and if it is susceptible of pictorial illustration, the cartoons must at once suggest the point aimed at, and be drawn by the hand of an artist. If this is done, and the reader is thereby more strongly impressed than he would otherwise have been, the argument that the end justifies the means may apply with much force.

Facts and Fancies

A POSSIBLE SOURCE OF INJURY TO THE EYES

The misuse of light is not the only thing to be avoided in protecting the organs of vision. Dr. S. Strode Jeffries, in a letter to the *Scientific American*, has the following warning in regard to the use of wood alcohol:

"A number of well-authenticated cases have been recorded from time to time, of persons who have lost their eye-sight from the mere inhaling of the vapors of wood alcohol, as well as from its use externally in liniments. Painters are specially subjected to the dangerous effects of this poison, and some of the cases referred to were those engaged in using shellac varnish, who had by continued absorption impaired their eye-sight and finally become totally blind. That methyl alcohol is poisonous externally as well as internally is no longer a debatable subject, and too much publicity of the facts cannot be given."

As the use of wood alcohol as a burning fluid for chafing dishes, curling-iron heaters, and other similar heating purposes, has become common, it will be well for those using it to exercise due care. The fact that the ordinary or grain alcohol "denatured," that is, rendered unfit for drinking purposes by the addition of small quantities of otherwise harmless substances can now be sold without paying the government duty of $2.00 a gallon, there is little to be gained by the use of the more or less dangerous methyl, or wood alcohol. The eyes are too precious to take any chances of their injury.

A NEW PROCESS OF GENERATING ELECTRICITY

It has long been known that when it comes to producing artificial light, man is a great bungler compared with certain insects. In the matter of efficiency he literally cannot hold a candle to a fire-fly—for the fire-fly produces light with an infinitesimal expenditure of energy as compared with a candle. It now appears that the moral holds true in regard to the production of the electric current as well, and with all his boasted knowledge and mechanical skill his best dynamo electric generator simply is not in it with the electric eel. A recent writer in the New York *Sun* has a short article on this most interesting zoological specimen. He reports having received his information from Prof. Don Quixote de Esperando, head of the Government college of Venezuela. The name of this professor has a suspicious sound —but let that pass, and hear what he has to say.

The electric eel, as is well known, is a habitat of South American waters, the Orinoco River containing countless numbers of them, and the Professor has for many years been convinced that a new source of energy could be obtained from them, and to this end he had a hundred average sized eels captured and copper wire put around the neck of each, just below the ears, and then connected them with a motor, the eels in the meantime remaining in the river near the shore. But he found in practice that their contortions and violent flopping about soon tired them out and greatly lessened the electric current, which was very intermittent and unsatisfactory. He therefore procured another hundred and put them into a zinc bath tub, which he had in his house, and connected it with the motor and found that they produced about twenty horse-power; in other words, each eel gave off about 150 watts of energy (there being 746 watts in one horse-power), and with this supply he ran a grist mill and lighted up his house and grounds, the power from each eel being sufficient to produce forty-five 16-candle incandescent lights.

As to the commercial value of the great discovery, there can be no question. The Professor will arrive in New York in a few weeks to confer with prominent capitalists who propose forming a gigantic syndicate to control the whole thing, and a preliminary prospectus is now being issued showing the illimitable possibilities of the scheme, and as an illustration it shows that an ordinary twenty horse-power automobile can be run for twenty-four hours with 100 eels in a tank three feet long and one and one-half feet square and weighing complete less than 200 pounds. In fact, it is claimed that the largest ocean

steamers afloat can be run with 200,000 eels, producing 40,000 horse-power, and contained in a tank not larger than 10 x 10 x 15; this plant, of course, will have to be duplicated so that when the energy in one is exhausted it can be hoisted from the hold to the boat deck, so the light from the sun can infuse new energy into it, it being replaced in the meantime by the other plant.

Wonderful as all this may seem, it is no more so than the telephone or wireless telegraphy.

To the unsophisticated this reads like a genuine scientific article, almost as much so as did some of Poe's remarkable canards. The *Electrical Review* in a recent issue, does some figuring, and comes to the conclusion that, at least so far as ship propulsion is concerned, it would probably be better to harness the eels to the ship and let them tow it by main strength.

There is ample material here for the jokesmith to ply his trade with. A string of eels instead of the trolley wire, with the generating plant cut out altogether: a small aquarium, with a trained eel lifting an incandescent lamp on the end of his tail, in place of the kerosene lamp or portable electric, are simply thrown out as suggestions. Numerous other applications will doubtless suggest themselves to the reader at once.

MUNICIPAL LIGHTING PLANTS IN WISCONSIN

The first municipal electric light plant in Wisconsin was established at Bayfield in 1889, five years after the beginning of the electric lighting business in this State. At that time there were thirty private plants in operation. The latest figures, those of last March, show forty-six municipal and 123 private plants in the State.

Of the 123 private plants thirty-eight are in places of less than 1,000 population, which is true also of thirteen of the forty-six municipal plants.

Of these the first eleven have the electric light plant operated in connection with the municipal water works. Only one plant, that in Hudson, is leased to a private company.

The strength of the municipal ownership movement is in the cities of from 1,000 to 10,000 inhabitants. Wisconsin is one of the twenty-four States of the Union which have no cities of over 10,000 population with municipal electric plants. In the last twenty-five years the number of municipally owned electric light plants has increased from one to 1,050 and the number of private plants from seven to 3,234; that is, in 1881 the municipal plants were nearly 13 per cent. of the whole number of plants, while in 1905 the municipal percentage had arisen to over twenty-four.

REDUCING THE COST OF INCANDESCENT LAMPS

In the beginning of the career of the incandescent electric lamp, about 75c. worth of platinum was used in a single lamp, and the bulb was blown by hand from a piece of tubing. At the present time the platinum in a lamp costs about ½c., and the bulb, which is made in large quantities at the glass factories, costs about 2c. It may appear from this that the present selling price of such lamps—18 cents for the ordinary size—is unnecessarily high; but when it is considered that there are some 50 operations in the process of manufacture, nearly all of which requires special skill, and many of which involve refinements of manipulation, which are nothing less than marvelous, this thought changes to one of wonder that the price can be made so low. Nevertheless, manufacturers are continually seeking to reduce the manufacturing cost; and a saving which would represent one or two-tenths of a cent on a lamp would be well worth considering.

An inventor in Toledo, Ohio, has constructed a machine for blowing the bulbs, which is said to reduce the cost to about one-quarter of the present amount. While the name of the inventor is not mentioned, it is very likely the same one who has perfected a bottle blowing machine which is revolutionizing the whole blown glass industry; so that there seems little doubt of his accomplishing similar results in the manufacture of lamp bulbs.

Platinum is more valuable, weight for weight, than gold, and the limited supply is controlled by the Russian government. Innumerable attempts have been made to find some substitute

for this expensive metal in the manufacture of incandescent lamps; but while many devices have promised well, none have come into practical use. We understand, however, that Maxim, the noted English inventor, has, after long study and research, succeeded in producing a metal which, when drawn into wire and platinum coated, answers the purpose of solid platinum in every particular. The metal has been tried on a commercial scale in England with apparently satisfactory results.

A NEW GLASS HAVING REMARKABLE PROPERTIES

Glass has always been the very symbol of electrical insulation, and is at the present time very extensively used for this purpose. So common is this use that the idea of a glass having electrical conductivity is almost as contradictory to the established ideas of its nature as would be a glass having flexibility. Nevertheless, the apparently impossible seems to have been achieved, as will be seen by the following:

At a meeting of Section A of the British Association, held recently in York, England, Charles E. S. Phillips described a glass which conducts electricity fairly well. This is obtained by fusing together sodium silicate and borax in the proportions of thirty-two of the former and eight of the latter. By adding one and one-quarter parts of Powell's flint glass to the mixture, greater stability is obtained and a better surface secured without any serious loss of conductivity. Such a glass is suitable for the cases or windows of electrostatic instruments. It may be cast into plates, but is not very workable on account of its low fusion point. It may, however, be drawn into rods or fibers, and takes a fine polish. It is somewhat harder than ordinary glass. The density is 2.49. It is transparent to X-rays, shows no fluorescence under cathode radiation, and is opaque to ultra-violet light. Its electrical conductivity is about 500 times that of the most conducting glass so far made. Its specific resistance is given as 10^9 ohms at twenty degrees centigrade. The glass may be powdered and fused onto clean copper, to which it adheres well without cracking.

The practical interest of this glass to the illuminating engineer is in the statement that it is "opaque to ultra-violet light." In a previous issue, we mentioned in this department the claims of an optician to making spectacles of a glass which transmitted the ultra-violet rays, and suggested that this was a decided disadvantage to the eyes, and that if a glass could be found that would absorb these rays, it would be of real value. According to the above report, such a glass is at hand. Its use in the manufacture of shades for light sources that are strong in the violet and ultra-violet is a matter well worth the attention of both illuminating engineers and manufacturers.

THE DANGERS OF WATER GAS

Suit has been brought against the Buffalo Gas Company to compel it to cease furnishing water gas to the city and individual consumers and to compel it to furnish illuminating gas. In the moving papers is an affidavit by Albert P. Sy, assistant to City Chemist Hill, in which he describes water gas and coal gas and delcares that water gas is more dangerous to human life. He also describes its deadly effects on guinea pigs. He says:

"Under ordinary circumstances and in small quantities illuminating coal gas is not considered dangerous to life and health. Recovery from accidental poisonings is usually rapid and complete. There is danger of chronic poisoning by continued exposure to illuminating coal gas due to the presence of a small percentage of carbon monoxid in such gas. Water gas, either raw or carbureted, is exceedingly poisonous, due to the presence of a large percentage of carbon monoxid. The poisoning by carbon monoxid is brought about by a union of the carbon monoxid with the hemoglobin of the blood, producing a chemical compound. Recovery from such poisoning seldom occurs, and is said never to occur after complete saturation of the blood.

"The inhalation of air containing a very small quantity of carbon monoxid by a human being will produce unconsciousness in a very short time, and if continued for any length of time will result fatally. One-tenth of one per cent. of uncarbureted water gas is injurious to health. One per cent. in air becomes fatal in a comparatively short time. The use of water gas for domestic and lighting purposes is extremely dangerous from leaky equipments and fixtures."

Correspondence

FROM OUR LONDON CORRESPONDENT

Much interest has been taken in a paper read before the British Association, at their Annual Conference held at York, on "The Manufacture of Light," by Professor Silvanus Thompson. In the course of his remarks the gifted speaker said: "That without making allowance for the cost of mantles, incandescent gas light was theoretically not more than one-sixth as expensive as gas burnt in the old-fashioned burners; and, as is, of course, quite well known, and accepted by all illuminating engineers, when the gas is burnt under pressure, the cost of gas is still further reduced."

He also drew attention to the "Millennium" gas light, and the many improved electric glow lamps, in which osmium, tantalum, zirconium and tungsten were used for the filaments. The new British Cooper-Hewitt electric mercury vapor lamp was described, and the Professor said it was a remarkable production.

The various forms of light were exhibited and a table given showing their relative theoretic efficiencies. These are given in the following figures:

	Candle-Hours for 1 Shilling.	Poison, Cubic Inches, Carbonic Acid.
Gas (bat swing) ...	2.700	536
Paraffin light	7.895	366
Welsbach mantle ..	12.500	72.5
Millennium light ...	25.494	39.0
Flow lamp	3.745	....
Nernst lamp	5.882	....
Osmium lamp	7.143	....
Arc lamp	10.000	2.2
Flame arc	46.619	0.8

"All were," he said, "of the opinion that enormous strides had been made in recent years in both of the most important methods of illumination. Gas illumination which cost a shilling to produce only a few years ago, was now produced by compression at less than a penny; and, so far as public lighting was concerned, the same might be said of electricity—for the flame arc was wonderfully cheap."

Professor Thompson told the meeting that he was in a position to show them what was really the last word in gas illumination. On a 10-light bar, he showed a flat flame burner, a Welsbach-Kern burner, and a new inverted gas lamp.

Duplicate incandescent lamps—with ordinary low pressure gas burners—had air injected into them by means of a hydraulic pump, to show the increased value of light which could be secured by this simple method. A series of lights of from 500 to 1,300 candle-power were shown with gas under a pressure of 54 inches; the gas supplied was compressed in an electrically-driven "Coloma" machine, governed without either gas bag, water tank, or springs.

We have reason to know that there are at the present time several small compressors, which have passed the experimental stage, and which are at no very distant date, to be exploited by a large commercial undertaking, which will give an enormous impetus to the use of inverted burners, and must work quite a revolution in gas illumination. At present we are not in a position to publish the details of either apparatus or results, but in a future number we hope to be at liberty to refer fully to the subject in these notes.

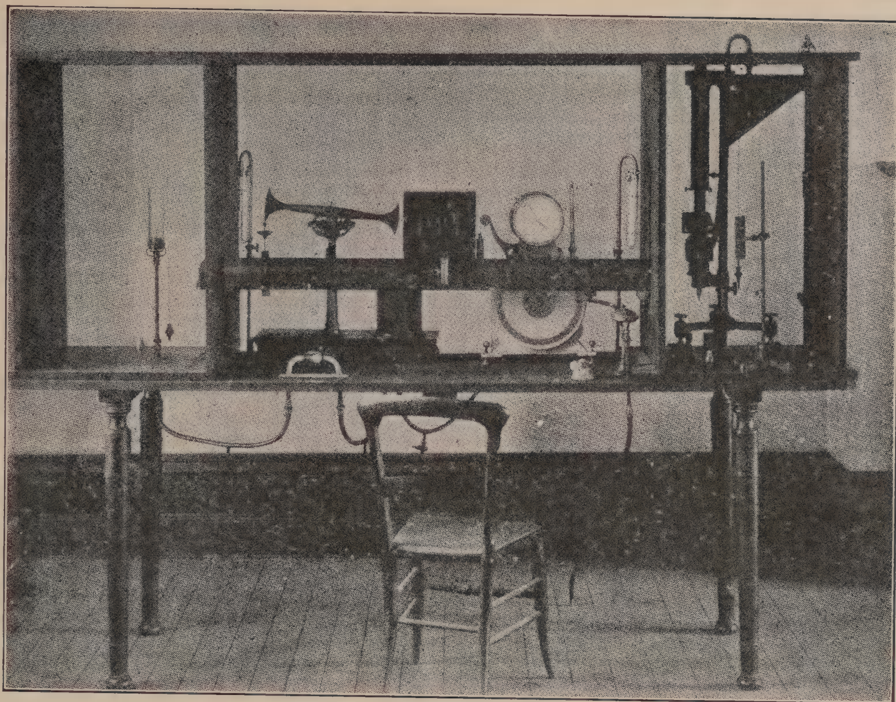
At the same meeting Mr. A. Q. Martin, M. Inst. C.E., read a very valuable paper on "Cheap Gas for Light, Heat and Power." The chief point suggested was the long distance transmission of gas; a subject which we remember to have been dealt with at great length, and with much ability,

by the late Sir C. W. Siemens, who in 1881, read a paper before the Gas Institute on "Gas Supply," both for Heating and Illuminating Purposes." His scheme was to manufacture gas at the mouth of the coal pits and transmit the product by pipe lines—under pressure—to the districts where it was required for use. For all these years the subject has remained practically dormant, and it has been left to Mr. Martin to set forth in no uncertain language the possibilities and advantages of the long distance transmission of gas. He has worked out in considerable detail a scheme for supplying London with gas manufactured in the vicinity of the South Yorkshire coalfields, which are distant about 170 miles from London. Estimating the consumption of gas in London at 40,000,000,000 cubic feet—which is rather under than over the mark—he suggests that this quantity might be carried by a single pipe line of 25 inches diameter, under an inital pressure of 500 pounds. The power required for compression, during the period of maximum consumption, would be, he says, about 40,000 horse-power, and it is suggested that the greater part, if not the whole of the steam required might be raised by means of the waste heat from the retort furnaces. The particulars of cost would not perhaps interest readers of this journal, but taking the cost of coal at the pits as $1.45 per ton, he figures out that the cost of gas delivered into the existing gasholders of the London Gas Companies would be about 7½d. (15 cents), per 1,000 cubic feet. The paper from the gas makers' point of view, is exceedingly interesting, and even startling; but at present there are many points which render his scheme anything but practical—not the least of which are the vested interests of the London Gas Companies, and the enormous sacrifice of plant and machinery that would be involved. Still, such a scheme shows the trend of thought, and deserves the fullest consideration of all interested in the economic manufacture and distribution of gas.

The artificial lighting of rooms and workshops is a matter which is of great interest, and all details pertaining to the subject are valuable to those connected with the science of illumination. The table we are now going to give throws a good deal of light upon a matter which is not sufficiently considered, viz.: The reflecting powers of various surfaces; the figures have been worked out by Dr. Sumpner, principal of the Birmingham Technical School. They are the results of careful experiments and are reliable.

If a room be white all over and a lamp of 100 candle-power be placed inside it, 80% of the rays of light striking the wall, ceiling, and floor, will be reflected; as a consequence, the illumination is equal to that given by another lamp of 80 candle-power; but if the room be papered and painted brown, the additional illumination by reflection, would be only 15%. The conclusion, says the writer of a paper

Surfaces.		Per cent. 2 Lights falling upon.
Mirror	Interflect.	95 per cent.
White paper	"	80 " "
Planed deal, clean	"	45 " "
" " dirty	"	20 " "
Yellow wall paper, clean	"	40 " "
" " " dirty	"	20 " "
Tracing cloth	"	30 " "
Blue wall paper	"	25 " "
Brown wall paper	"	13 " "
Deep chocolate	"	4 " "
Macadam road	"	8 " "
Dead black surface	"	1 " "



OPEN BAR PHOTOMETER FOR GAS TESTING.

on the subject, Mr. A. E. A. Edwards, M.I.M.E., arrived at is, that a 20-candle-power lamp in a white room will give the same effective illumination as a 100-candle-power lamp in a black room.

An ordinary plain glass window obstructs from 7 to 10% of the light falling upon it.

Ribbed	glass	obstructs	...15 to 30	per	cent.
Opaline	"	"	...15 to 40	"	"
Flame	"	"	...30 to 60	"	"

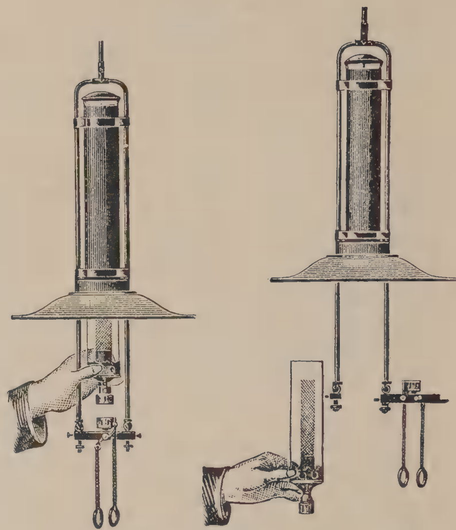
These are matters for consideration which are too often overlooked; still further obstruction, is of course, caused by the glass becoming dirty.

The testing and photometric measurements of gas finds a place in the columns of THE ILLUMINATING ENGINEER, and so we draw attention to what is known as the open bar photometer. Mr. R. O. Paterson, who for many years has been resident engineer of the Cheltenham Gas Works, has recently adapted an open bar photometer to meet the requirements of the testing clauses specified by the Metropolitan Gas Referees, who are the authority governing all questions of gas tesing in London. For the illustration given, and the particulars, we are indebted to the *Gas Journal.* Mr. Paterson has devised the arrangement for use with the 10 candle power standard, and the first and chief point of importance is that as the pentane flame is exceedingly sensitive, it is necessary that the operator, when once he has lighted the gas and the standard lamp, should not have occasion to move about the photometer room. It is also necessary that the atmosphere should be absolutely still. To maintain this most requisite condition, the operator sits in a chair and has at his left hand the micrometer screws for regulating the consumption of gas; and at his right hand the valve for regulating the pentane flame. In working with the bar photometer, it is distinctly found that there is a difference of light given out by the standard with

small variations in the height of the flame between the bottom of the window and the middle of the bar; as a consequence it is absolutely necessary that the flame should be maintained at one uniform point; and the arrangement achieves this as far as is possible.

The general description is as follows: A convenient height for the table is 2 feet 6 inches; the center of the discs being about 4 feet from the floor and to this line the centers of flame must be adjusted. A No. 2 Metropolitan Argand burner, with a thumb cock immediately below it, is placed preferably on the left of the photometer bar, and the standard 10-candle pentane lamp on the right. The gas micrometer, for adjusting the consumption of gas, and the regulating screw for the height of flame in the standard lamp are all in convenient reach of the operator. The meter and pressure governor must also be within easy reach and sight; the double governor, on the inlet of the meter, should also be under ready control. The pressure gauges on the inlet of the meter and the outlet of the micrometer, must be within view. A small mirror opposite the window of the pentane lamp will enable the operator to see the height of the flame without moving from his chair. To assist the reading, the photometer bar should be graduated to tenths and hundredths, as far as the figure 2, from the center, on either side in order to indicate the photometrical valves from 5 to 20 candles. The purpose of the apparatus has been thought out with much care and practical stillness for the operator is ensured.

Something new in a gas lamp has been put on the market by Messrs. James Milne & Son, of London, and Edinburg. The lamp which is illustrated, is of the self-intensifying type and has a long metal chimney to increase the draught and to induce the necessary supply of air to the burner. The special feature of the lamp is the method adopted for the removing and replacing of the burner. This will be at once grasped by a reference to the two illustrations. In Figure 1 the burner is being removed, the head, together with the mantle and chimney are raised; the glass chimney is passed up into the metal tube, the milled nut at the left hand is slackened, and the swiveling bar thrown on one side, so that the burner, mantle and chimney, can be removed, as shown in Figure 2. These lamps are designed for shops and factories; the simple means adopted for removal of the burner renders them most suitable for business premises.


NEW SELF-INTENSIFYING GAS LAMP.

The Illuminating Engineering Society

DISCUSSION OF DR. LOUIS BELL'S PAPER ON SOME PHYSIOLOGICAL FACTORS IN ILLUMINATION AND PHOTOMETRY

(Reported in ILL. ENG., p. 263.)

From the Proceedings of the Ill Eng. Soc.

President L. B. Marks.—One of the objects of this Society is to bring about cooperation between the various interests identified with illumination. We have heard from the electrical engineer, the gas engineer, the architect, the designers of fixtures, globes and reflectors, and from the chemist. This evening we shall hear from the oculist. We have the honor of the presence at this meeting of several distinguished oculists, and I will call upon Dr. Percy Fridenberg, president of the Harlem Medical Association, to speak on the general effects of light on the eye.

Dr. Percy Fridenberg.—The subject of photometry has been put before you in such a scientific and exhaustive manner that I have nothing to add in the way of discussion of Dr. Bell's paper, except to translate into figures of everyday-life one or two of the conclusions he has presented to you.

First, I will say a word in regard to Fechner's law, which states that the human eye can perceive a fixed fractional difference of illumination, within wide limits, irrespective of its absolute amount. That is to say, a fractional difference of 1 per cent. or one-half of 1 per cent. But when we translate this into practical terms, it means that there is a very large difference in the perception of different light, in regard to the initial illumination, whether it is high or low. If we have a room lighted with 1,000 candles, the addition of one candle will not be perceptible; but if we have only 10 candles, an addition of one candle will make a considerable change in the apparent illumination; and this should be borne in mind—the question of contrast and the question of proportional illumination. So there is a proportional in the Fechner law, for the idea is for all sense organs the same and it applies to weights.

There is another little point in regard to bright light and its effect on the pupil, and that is the fact that the diameter of the pupil is not a fixed value. It is not even fixed for any single illumination. It varies with age and refraction. The myope has not the same pupil as the far-sighted person; and so it varies with focusing. The eye adapted for distance is wide focused, and in focusing on near objects the pupil contracts.

Now, it seems to me that the effect of contraction on illumination has been somewhat overstated. If reducing the size of the diaphragm interfered with objects to that extent, we would be able to make a comparison of ourselves and be able to compare pupils. It does affect the amount of light which enters the eye, and it affects the luminosity of the entire field of vision; but our sharp, direct vision is limited to a very small area of the visual field. If we take the visual field of 180 degrees, the area of distinct vision is not more than a few minutes; so that the intensity and luminosity does not depend on the amount of the light illuminating the entire field, but does depend on the amount illuminating the objects seen. So we see that the pupil can be "stopped down" to the fraction of a millimeter without decreasing the illumination.

Another point was the question of adaptation. Dr. Bell mentions a patient who stumbled over an object, and whose Fechner coefficient was 1/10 of the normal. We find the same condition, however, when a person who has been in a bright light goes into a dark room. He will stumble over objects then just as this patient did. In him you have produced the same condition as in that diseased person. It takes some time before the eye becomes adapted to the darkness. At first its adaptation increases very rapidly. For a moment you see nothing at all, and then after a few minutes you see very well, so that after the first four or five minutes have elapsed the adaptation has been very considerable, and there is only a gradual increase beyond that point, so that at the end of fifteen or twenty minutes after entrance into the dark room you see very little more than you did after you were in there five minutes. The same thing occurs in an opposite manner when you reverse the condition and go out of the dark into a brightly lighted room, but the contraction of the pupil is then so violent that there is pain. The difference is disagreeable in its effect and vision cannot take place until the eye gets accustomed to the illumination, which may not be above normal. So we have always to consider the factors of contrast and adaptation.

If you take a low degree of illumination and increase it gradually, you can reach points theoretically beyond the normal. That is a law connected with sensation. I read of an experiment where a frog was put on a metal plate, which was very gradually warmed—a few degrees in the course of several hours—and the plate finally heated until the frog burnt up, and the frog did not move. That is an absolute physiological experiment. The same thing

is true of other senses—a gradual increase or a gradual decrease of stimulus carries with it a very marked adaptation.

Now, so much for the physiological question. There are one or two pathological questions which we must consider, that is, those relating to the disease of the organs, the eyes. The question is often asked which light is the best for the eyes. Is the arc light best? What is the effect of the Welsbach? Is the incandescent light good? And a number of such questions are constantly being asked; and while I must admit that I haven't studied this question with sufficient exactness or thoroughness to give a scientific answer in regard to the various lights, I think the main stress must be laid on practical considerations. I think the factor of light intensity is of much more importance than those of light value, wave length or of physiological consideration.

The question is, What light will give sufficient illumination without too great intensity? In what way should the illumination be distributed to get maximum lighting effect with least wear and tear? And there is then the question of distribution of light, rather than the nature of the individual source of light.

There is one point in regard to incandescent light which may have something to do with its bad repute in regard to its effects on the eyes, and that is that it can be brought closer to the eyes than the light of a candle or a gas light or a Welsbach light. Thus we have there other factors to consider beside illumination. In the first place, we have heat—a factor which very markedly affects the eyes. I will have, for instance, a flexible holder that allows me to place the light within 6 or 7 inches of the eye. At that distance you will get a very marked degree of heat, which will dry out the surface of the skin and of the eyes, and cause a sensation such as one would have if he stood in front of a fire or a stove where there was not much bright light.

Now, any kind of light which is strong enough can affect the eyes injuriously. Direct sunlight can be very dangerous. There are cases where the retina has been burned at its central point by people trying to look at the sun and keeping it up. As you all know, in such a case you have an intensely bright after-image. That is simply due to the persistence of irritation after the stimulus is out of the field of vision. If you persist in the attempt long enough, the after-image will persist for considerable periods and there will be something almost amounting to blindness. Experimenting with intense electrical discharges has given a similar blinding effect, which is usually only temporary. We hear of workmen whose eyes have been exposed to flashes caused by short-circuiting, or in electrical welding, and they believe in some instances that they are stricken blind. The immediate effect of this flash upon the eye is to cause intense inflammation near the lids, and this causes intense pain when you try to open the eye, just as if you had had a lot of dust thrown into your eye. The eyes are closed, and it is difficult to open them, and these people think they are blind; but in only a very small number of cases is there any lasting effect on the vision. The same pain is caused by exposing the eyes to the reflected sunlight from snow; and the arctic explorers have all put on record how painful on the eyes the first few days on the snowfields were. A good many of the natives wear goggles made of horn with a thin slit across the center. Without the aid of such a diaphragm the conditions are intense inflammation of the lids of the eyes and in some cases partial blindness.

Now, the questions of practical illumination have been brought before your Society by gentlemen working in other fields. The question put to us by parents and by school teachers is more in regard to the daylight illumination in school rooms; but what applies there will of course also apply to other rooms than school rooms, and to other rooms that are used at night with artificial illumination, for teaching, study, libraries, etc. Here again the question of the intensity of the light source and its proper placing is much more important than the theoretical consideration of wave length.

Most of our public places are too brilliantly lighted—the restaurants, the hotels and the theaters. Ideal illumination would be that in which the object to be seen is illuminated, and the minimum amount of light enters the eye. The ideal illumination of an object on a wall would be to look at it through a telescope tube blackened on the inside. In that way you would get illumination on the object you wish to see and the light from all the other sources is shut off. That brings us to the question of the concealment of light sources as much as possible, and the distribution of the light, giving a wide distribution rather than high illumination on one or two points.

We medical men have a term in regard to the treatment of patients termed "individualization," which means to study the needs of a particular case, and not to try to put everything into one frame. The room in which a blackboard demonstration is going on may require bright illumination on the blackboard and very little on the walls. In the case of a gymnasium or a ball room, they require a different form of illumination. A broad diffuse illumination for a ball room, or for a gymnasium, will not be the kind adapted for a room where you are demonstrating something on a blackboard, or a chart. or reading a man-

uscript. In these last mentioned cases the illumination should be brilliant on the chosen object.

The question of blackboards as affording a contrast for light is of importance. The coloring of walls and ceilings becomes, in large demonstration rooms, or lecture rooms, or libraries, of very considerable importance. There we might have a general illumination on the objects to be seen, but a badly colored background will undo much that is done by a good light. A great deal of attention should be paid to color. Color, of little importance in the light source, is of vast importance in a background; and we are taught that the most agreeable backgrounds for the eyes are those containing a great deal of gray. If the eye is constantly exposed to one form of light in primary colors, that irritates only one set of fibres, namely, those that respond to that wave length. White light stimulates all of them, and you have the three sets of fibres used in that case. White or composite light will naturally be more intense than light of a single wave length. It is almost impossible to give a red, green or blue light which will be as intense as a possible intensity of white. Backgrounds, if neutral, such as grays, will give most rest to the eyes, because they produce little color sensation. If a little color is put in with the gray, it will not cause much color perception or fatigue; so we have to compromise between what we ought to do and what we have to do, and it comes down to using backgrounds as sober as possible in connection with the question of illumination. Walls, particularly in school rooms and where good light is important, should be gray-green, or a gray-blue, or gray with a faint suggestion of yellow; either of these, not too marked with the color, are good, restful backgrounds to the eye.

The President.—Dr. Niel J. Hepburn, of the Manhattan Eye and Ear Hospital, is with us this evening. We shall be very pleased to hear from him.

Dr. Niel J. Hepburn.—The previous speaker has covered the ground so thoroughly that there is not much left to a subsequent gleaner. I do not know whether the subject of retinal irritation in regard to light has been taken up. The main question has been the matter of the intensity of light, and in a great majority of the cases the object has been to get an exceedingly powerful light, with the resultant discomfort. Now, where I work I find that semi-subdued light gives best results, and it is certainly much less irritating to the eye. There was a curious observation made during the war between the allied forces and China in regard to the visual actuities of the men there representing the different Powers. To sum it up, I think the conclusion was that those contingents that came from countries where there was a large number of cloudy days had better vision than those that came from sunshiny districts—all of which went to prove that the quality of light, rather than the intensity, is the main factor. Another thing borne out by that conclusion was that the yellow lights, rather than the white lights, are the most grateful to the eye; and when we go to our ordinary work I think we find pretty much the same thing. I think in actual orthomoscopic work we find the yellow flame is better for the patient and gives better results than the incandescent light. I know of a number of experiments with ground glass globes and others of that kind, to do away with the image of the filaments, and then with the keen intensity of the light. Some of us have fallen back on the old gas flame, and some of us have even gone back to the kerosene flame of the lamp, because it is a steady flame. The continuous uninterrupted power of the light, without any break, is a considerable factor of advantage. In regard to backgrounds, I have arranged my office so that I have a very light yellow tone with a gray; and people entering there make the remark that it looks so restful.

The President.—I see Dr. Dennett is here with us this evening, and I am sure he will be listened to with interest.

Dr. W. S. Dennett.—It gives me great pleasure to come here to-night. I am glad to know somebody is interested in illumination besides the few patients who ask me occasionally about it. The old-fashioned idea of illumination, that is, for reading and writing purposes, was to put an old-fashioned light as close to your left shoulder as possible, having no light on the rest of the room, but all the light you could get on the book in front of you; then you could read and try to think you were happy. That is all over with me now. I am in the habit of telling people who ask me what they shall read by at night, and whether it shall be a Welsbach, or an electric light, that a well-known authority by the name of Cohn said you could not get too much light. It is pretty hard to get more light than you can get from the sun. However, you can get it from inconvenient places. I put my light overhead and I sit where the gloss of the paper doesn't irritate me, and I take pains to see that my hand does not throw a shadow over what I am writing. Then if there is enough light and it is a steady one, I think I should be satisfied. It is a question for illuminating engineers to tell whether it is most economical to do your reading by a red, yellow or a green light. It is very easy to find that out; at least I suppose it is from the paper we have heard to-night, which is one of the most valuable I have ever heard on this subject. I want to say

further that this is the most beautifully lighted hall I have ever been in. The lights are behind and above you, and the walls have a pleasant neutral color; the room seems to have been lighted by people who knew how to get the comfort and brilliancy of proper illumination.

As for the color of light, I do not think that makes very much difference either in its bearing on health or comfort. Whatever your light is, if so bright that it hurts you to look at it, it should be so placed that it is inconvenient to look at it; and then whether incandescent, or arc, or mantle, if there is enough of it, and it does not jiggle, it is a pretty good light. But arcs will sometimes flicker, and incandescents will go up and down when something happens at the central station, and if it does not happen as much as forty times a second you can see it happen. But you gentlemen know how to prevent that.

If your light is steady, the color is not of much account, except from your standpoint of economy, and of course that is your side of it. Many of these forms of light may or may not be artistic; but I do not think the color makes much difference, or at least I did not think it until Dr. Fridenberg spoke of the tiring effect of putting all the strain on one set of nerves. Prof. Rood once told me more energy came with sunlight than with any artificial light, and if the sun doesn't hurt you I do not think you should be afraid of any light on the market. And so commercially, practically, and professionally, you may have any light you wish if you do not get it too much in your eyes, and it is steady. The situation where you are reading in a dark room, with a light very near, is that every time you look at your book you make your pupil small, and then when you look up the room is dark and there is a sudden change of adaptation of the pupil which is tiresome. So, get all the light you can get, if it is steady, and be thankful for it.

Mr. William D'A. Ryan.—Briefly, Dr. Bell's paper points out the value of even illumination, of low intrinsic brilliancy, with the light source out of the direct line of vision. As for the question of intensity, we have not yet reached a point of over-illumination. A few years ago arc lamps on from 25 to 30-foot centers were considered very good. These distances have been closed up in many places until they are now installed on from 15 to 18-foot centers, and even under these conditions the intrinsic brilliancy is not high enough for comfortable and satisfactory selection of colored goods. It is safe to state that the intensity of illumination can be carried up two or three times the present values without exceeding the point beyond which additional illumination adds little to the ability to distinguish with greater clearness. If lamps of higher efficiency than those used at the present time are placed on the market, it will not necessarily mean a reduction of the total power consumed, but people will be educated to the use of more light.

It has been intimated this evening that yellow light appears to be easier on the eyes than white light. I think this is a matter of intrinsic brilliancy rather than color. Aside from the question of light there is no doubt that the heat from an incandescent lamp suspended near the workman's head is troublesome and injurious. I have found by experience that workmen who are provided with a good even general illumination raise less objection to working nights than those who are obliged to work with a spotted illumination produced by localized light. I do not think it is putting it too strong to state that the placing of lights in the direct line of vision in public buildings and elsewhere will sooner or later be prevented by law. There is a general tendency towards semi-concealed and totally concealed lighting, which will grow more rapidly as the efficiency of the illuminants improve; at the same time there is what might be called a class of intrinsic brilliancy fiends, who do not feel that their places are being properly lighted unless there is more or less glare. This class of customers can undoubtedly be educated in time.

Mr. E. Y. Porter.—The last speaker summed up the paper of the evening excellently. What we want is lots of light—distributed light, and light of low intrinsic brilliancy. It is remarkable how much is now sacrificed to obtain low intrinsic brilliancy. Take the arc lamp. First it was the bare arc with a brilliancy of 3,000 or 4,000 or even 5,000 c. p. per square inch. Next the arc was put in an opalescent globe, and then we enclosed that opalescent globe within another globe, an opalescent or a ground glass globe, bringing the intrinsic brilliancy down very much as compared with the starting point, but with a loss of one-half to two-thirds of the light. You are sacrificing very much in the efficiency, but it is worth while, and I think everyone will agree that the ground glass globe enclosed arc is much better than the exposed arc; and yet we are doing it at a sacrifice of more than one-half the efficiency.

This room in which we are to-night is another good example. We have a certain intrinsic brilliancy on the walls just above the concealed incandescent lamps. That wall is the direct illuminant. That is pleasant to the eyes, simply because it is of low intrinsic brilliancy. The illumination of this room is good simply because of the large area of light source, i. e., the

reflecting wall and ceiling; so that the total amount of light which we have here is sufficient for proper illumination. Therefore, it seems I can define the ideal light as one which shall disseminate the light from a large area at low intrinsic brilliancy, steady, high efficiency, normal daylight color, and of sufficient volume to bring the illumination of the room to or above the limits mentioned in the paper read this evening.

I feel I am only doing justice to the inventor and his associates, as well as a service to the science of illumination, in calling attention to the "Moore Light," which has been consistently developed with the purpose of producing a light of this kind. It is nearly ten years now since Mr. D. McFarlan Moore read a paper before the American Institute of Electrical Engineers in which he called attention to the need of low intrinsic brilliancy, with large area of light source, and that idea has been carried out in his own work, so that the "Moore Light" as produced to-day starts with an efficiency as high as 1½ watts per c.p. and at an intrinsic brilliancy of from ¼ c.p. per square inch to a maximum of about 1½ c.p. to the square inch. This is a brilliancy which cannot be objectionable to the eye, as there is no need of sacrificing initial high efficiency or covering or concealing the tube to diffuse the light, since it is already so thoroughly diffused. Moreover, the color and intensity can be adapted to the necessities of the case in hand.

Mr. Ryan.—Is that candle-power the mean spherical, or the candle-power at right angles to the tube?

Mr. Porter.—The candle-power is measured by taking a small section of the tube, ¼ or ⅛ foot, and comparing it directly with a standard Hefner lamp in a portable photometer. That section, 1½ inches by 1½ inches, compares approximately in size with the incandescent lamp; and the light is measured at right angles to the axis of the tube.

The President.—The remaining speakers will be limited to five minutes. We will now hear from Mr. Cravath, of Chicago.

Mr. J. R. Cravath.—I have not given the paper sufficient study to discuss it intelligently, but some of the practical points which have come up since the paper was read I would like to touch upon. Let us consider the statement made on page 5 of the paper, where Dr. Bell says: "Therefore it plainly appears that at 1 or 2 foot-candles the eye is working so near its normal sensibility that further increase in illumination is of relatively very small value."

I quite agree with him in his conclusion that 1 or 2 foot-candles is sufficient for ordinary reading; but I do not agree with him that it is at all sufficient for close work such as draughting, or anything like fine work. In the case of draughting, where a draughtsman must trace through a thickness of tracing cloth and where the actual foot-candles under the tracing cloth is the important point, I do not think 10 foot-candles are too much. I agree with Mr. Ryan and the other speakers that we are not in practice likely to reach an unsafe intensity of illumination. We must consider, however, that with very intense sources of light the reflection from paper and other surfaces upon which we are working is much more hurtful physiologically than if we were working by daylight; so with artificial light we have to be careful about our intensities unless we see that our sources of light are well diffused.

One other point, and that is as to the effect of reading in a darkened room with a bright light on the paper and the rest of the room comparatively dark. My position, based on my own personal impression, is that we can go too far in, or not far enough in, darkening the sides of the room; I think there is a happy medium. The eyes crave a little rest from reading and occasionally we glance up, possibly only for a small fraction of a second, but it gives the little rest needed. Of course, when we look up, if we glance into a dark room the change is very great, while on the other hand, it may not, with brilliant general illumination, be great enough to be restful.

A question on which I should like to hear is whether it is advisable in an audience room or theater, supposing we want to bring out objects on the platform or the stage, to turn out entirely the lights in the back part of the room and leave only the stage or the platform lighted? My impression is that it is easier on the eyes if we do not darken too much the rear part of the room. I think that mignt be discussed with profit.

A Member.—Answering Mr. Cravath's question as to whether it is more desirable to have some of the lights in the rear of the audience rather than on the stage, I speak from observation. I find it is easier on my eyes if some of the lights not connected with the footlights are burning; and I find I can see better when there is a calcium light projected from the rear, rather than when the lighting is all from the stage footlights.

Dr. Clayton H. Sharp.—I wish to draw attention to a statement appearing on page 10 of the paper read this evening: "The comparison of colored lights involves this phenomenon to a very serious extent, and in particular all extinction methods are vitiated by it, save when used merely for the comparison of lights of similar color or for the actual measurement of very low intensities. Any photometric device which can be used on colored lights with co-

herent results by both the normal and the colored line, owes its apparent efficacy to the disregard of part of the spectrum which is generally useful."

In this connection I wish to draw attention to the fact that the electrical engineer instituted a comparison of street lights by the extinction method; that is, by using different sources of light in deciphering print.

This statement of Dr. Bell's, with which I heartily agree, points to a source of error which may be incurred by using this method in comparing lights of different color; and I think this Society should oppose the introduction into common practice of this method of comparing lights until we are better satisfied of the value of it.

Mr. E. L. Elliott.—The statement of one of the speakers, that, "as long as we have plenty of light and are comfortable, is all that is necessary; we need not trouble ourselves about getting too much," reminds me of Dr. Wilder's advice as to food. He said: "So long as you have sufficient to eat and it is decently cooked, you needn't bother about what it is." However, I think there is a limit to be placed on the statement; one may eat too much, even of good food; and doubtless more stomach troubles are due to overeating than to the bad quality of food. I think the same thing may be true of light; we *can* get too much.

One of the most common maxims set down by those treating of illumination is that light sources should be kept high up, out of the line of vision. That seems an obvious truth, and I know I began preaching about it ten years ago, when I first became interested in illumination, and continued until I found I was mistaken. I found there were positions for lights that were worse than on the level with the eye. I found in a room in which there was a cluster of three lights placed almost directly over my head, that it was impossible to read without excessive strain on the eyes. That led me to observe similar cases, and judging from my own observation I have come to the conclusion that strong lights high above are at least as fatiguing as lights on a level with the eyes. I have accounted theoretically for this by assuming that light coming down from overhead strikes the eye at an unusual angle, and is fatiguing for the same reason that light reflected from snow is fatiguing. Even the frosted lights in this room were fatiguing to me when I entered. I think I would prefer to have them on the line of vision and diffused, rather than on the ceiling and exposed.

Mr. C. H. Vom Baur.—There is one thing which Mr. Ryan brought up, and that is, he said he thought a person would get red blind by working under a mercury arc for six months. I have known men to work for six months, a year, and even a year and a half under these mercury arc lamps in machine shops and other places, and they are still able to distinguish a carnation from a corn flower.

Mr. V. R. Lansingh.—I wish to call attention to the practice of the Treasury Department of the United States Government relative to the intrinsic brilliancy of globes. The engineers appreciating the necessity of diffused light, endeavor to keep the intensity as low as 1/6 of a candle-power per square inch, which is perhaps below the ordinary standard practice. By this is meant that if in a globe 6 inches in diameter having a surface of about 96 square inches a 16-c.p. lamp were placed, we would have 6 square inches of surface per candle-power. This is simply the method of rating adopted. They endeavor to bring diffusing globes on the same chandelier to the same intensity per square inch. Thus, if a 12-inch sphere and a 6-inch sphere were on the same chandelier, four times the candle-power would be placed inside the 12-inch that is in the 6-inch as the surface area would vary as the square of the diameter.

Mr. Bushnell, of the Chicago Edison Company, has had a great deal of trouble with his eyes and has undergone a long siege with the oculist. This, he claims, is due to the painful effects of red rays, inasmuch as he was compelled to work many hours under artificial light. In order to correct this effect, he wore blue glasses for a long while. He, therefore, claims that an illuminant with its maximum intensity in the lower part of the spectrum is much more harmful than one having its predominant rays in the upper part of the spectrum. In plain language, even the enclosed arc light with its violet rays is easier on the eyes than the standard incandescent lamp. My own experience has been the opposite of this, and I should like to hear from some of the oculists present as to which they consider the correct view.

The President.—I think the answer to that question would involve a little study, but we would be glad to hear from Dr. Dennett.

Dr. Dennett.—I would like to say that I do not know.

C. H. Vom Baur (communicated after adjournment.)—Mercury arc lamps of the Cooper Hewitt type have been in factories, offices, and various other places for over three years, where they have given entire satisfaction in every way, especially with reference to effect upon the eye, this being due largely to its high glow value and its peculiar color. It has been proven that the color of the mercury arc in its diffused form does not break down the yellow pigment of the eye faster than it can be restored, which is another indication of its usefulness as an artificial illuminant. In further confirmation of the above, it is in-

teresting to note the opinion of Dr. Steinmetz, quoted below from *The Electrical World and Engineer*, of February 21, 1903, on the color of the mercury arc:

"The most prominent feature of the mercury arc is its bluish-green color. This is due to the deficiency of the mercury spectrum in red and orange rays. This feature is objectionable in some cases and advantageous in others, and will probably give the mercury arc a distinctive field of its own. Extended investigation showed that the harmful physiological effects of light, as observed when working for a long time with artificial illumination, are not due to the lower intensity of artificial illumination compared with daylight, but rather to the red and orange rays which predominate in the artificial illuminant. These harmful effects disappear by excluding the red and orange ray. The mercury arc, therefore, is the only known artificial illuminant which is perfectly harmless, and thus, it is especially suited for use where accurate work has to be done by artificial illumination, as in draughting rooms, offices, factories, etc. In this respect it differs from the Welsbach gas light, in which the greenish color is due to an excess of green rays, superposed upon an excess of red and orange rays, and which, therefore, does not have the same harmless feature.

"A strongly noticeable feature of the mercury arc is its penetrating power regarding distance. While the intensity of radiation obviously decreases for all colors proportional to the square of the distance, the sensitivity of the eye with decreasing intensity decreases much faster for red than for green and blue rays, so that the apparent physiological intensity of bluish-green light decreases with the distance much slower than with the red light; that is, of a red and green light of equal intensity the red light will appear much more intense and glaring at a short distance, while the green light will appear much more intense at a greater distance.

"For color matching, however, the light of the mercury arc is unsuitable, as is also that of the gas or kerosene flame, only that with the latter the blue appears blackened, while with the former the red appears brown and the blue retains its full brilliancy.

"The mercury arc gives specially brilliant effects wherever green is the preponderating color, and is thus best suited for suburban street lighting, lighting of country seats, greenhouses, etc. The suppression of the red colors gives all vegetation an especially vivid and fresh appearance, and the strong actinic character of the light gives a fluorescent sheen to many substances usually not recognized as fluorescent, such as glass, snow, etc. For indoor illumination in private residences the mercury arc is, owing to its color, not well suited, except when there is added to it the red and orange rays. This, however, lowers the efficiency owing to the inherently lower efficiency of red and orange light."

E. Y. Porter (communicated after adjournment.)—The question by Mr. Ryan relative to the method of measurement, and the mean spherical candle-power of the Moore tube light, raises an important and interesting point in photometry which it was not possible to touch upon at that time.

Properly speaking, there can be no such thing as mean spherical candle-power when applied to a light source having but one dimension, namely, a linear dimension. The term "mean spherical candle-power" is simply a roundabout way of expressing the flux of light from a given source, and has come into use only because the sources of light have hitherto been approximately points of light. When we speak of a source of light giving one "mean spherical candle-power," we really mean a source of such intensity that if its rays radiated equally in all directions from the center of an imaginary sphere of 1 foot radius, then the illumination on all parts of such sphere would equal 1 "foot-candle." Or, to put it in Hefner-metric measure—one mean spherical Hefner-unit, or one "lumen," is equal to the flux of light through one square meter of the surface of the sphere of a radius of 1 meter, when the source is a point of light of the same intensity as a standard Hefner lamp and whose radiation is equal in all directions. This is a unit applicable to all cases without reference to the form of illuminant.

Every part of a Moore tube radiates its light equally in all directions along planes perpendicular to the axis of the tube. There is also radiation from each particular point at other angles than perpendicular to the axis of the tube, but such dispersion is compensated for by an equal dispersion from adjacent sections of the tube, so that the effect is the same as if the light from each position—say each linear centimeter—followed only a path perpendicular to the axis, but in all directions along this perpendicular plane section. Therefore it follows that the dispersion is strictly proportional to the distance, or, in other words, that the illumination is *inversely proportional* to the *distance* from the tube instead of to the *square* of the distance, as in the case of light from a point. This fact is one of the causes for the remarkably uniform illumination of a room when lighted by a Moore tube. When a Moore tube is measured by the portable photometer used for the purpose, it is measured as a spot light. That is to say, a small section of the tube is compared with the light from a standard Hefner lamp, the result being simply a measure

of the intensity of the light along a line perpendicular to the axis of the tube in Hefner units; and since, as shown above, the intensity is the same at all points on an imaginary cylinder whose axis is the axis of the tube, we may calculate the total luminous flux directly in lumens for any tube whose length is great as compared with its diameter.

To take a concrete case, suppose 4 cm. length of tube were measured in a photometer against a Hefner lamp, and found to have an intensity of 2 Hefners or 0.5 Hefner per cm.; the total flux per meter length of tube will then be $0.5 \times 100 \times 2\pi = 314.16$ lumens; or in English measure taking one Hefner = .88 c.p. and 4 cm. = 1.58 inches, then $\frac{2}{1.58} \times 12 \times .88 = 13.37$ c.p. per foot, and $13.37 \times 2\pi = 84$ foot-candles per foot of tube.

Of course, there is a certain amount of light which follows lengthwise of a Moore tube and emerges at the corners, but no account is taken of this in figuring the efficiency, although it does assist in the general illumination of a room, especially if the bends are numerous and the walls of the room are good reflectors.

TOPICAL DISCUSSION BEFORE NEW ENGLAND SECTION

At a meeting of the New England section of the society, held in Boston on June 26, the following list of topics was presented for discussion:

1. To what extent in practice can the distribution curve of a lamp be modified, by shades or otherwise, to throw the light in certain directions?

2. Would you advise Welsbach lighting in large store windows?

3. Can Nernst lamps be run commercially in series, or arranged in any way for voltages above 240?

4. To what extent can the rule for keeping lights out of the range of vision be followed in halls, churches, etc.?

5. Is there any standard that can be used in the selection of Welsbach mantles?

6. What is the best economy with Welsbach mantles—to purchase a high-grade mantle and use it until it breaks, or purchase several cheaper grades for use the same length of time as the one of high-grade quality?

7. What is the best method of lighting high rooms, using small units, to get good distribution on the lower five feet of the room?

8. Is the present state of development of acetylene generating apparatus such as to justify its use with safety by non-technical people?

9. Do central station men use any system of replacement of series incandescent lamps when they have become blackened, as is frequently done with multiple lamps?

10. What is at present the most satisfactory means of measuring interior illumination?

11. Where colors are to be selected or matched by artificial light, what is the best method of determining the suitability of the illuminant?

12. In making a survey of, say, a dry-goods store, with a view to bettering the illumination, what is the best method of procedure, and how can the results best be presented?

13. To what extent can electric lamps that give off fumes be used for interior lighting?

14. For what purposes is the new flaming arc lamp best adapted?

15. To what extent is acetylene used for town and city plants, and how do the operating expenses compare with respect to water or coal gas lighting?

16. Can a mantle be used to any commercial advantage with the acetylene system?

17. What is the probable field of alcohol in connection with lighting?

18. What is the effect on the light and life of a Welsbach mantle of change in the gas pressure?

19. Is it ever practicable to use alternating-current enclosed arc lamps on a frequency of less than forty cycles; if so, in what cases would this be allowable?

20. What are some examples of the best illumination you have observed?

21. What would you suggest as the most practical means of increasing the efficiency of modern illumination?

22. What methods do contractors generally pursue in locating either gas or electric lights on new work?

23. What objection could be raised to a street-lighting system, whereby the lighting company would agree to furnish a certain number of light units per street mile?

24. Has the inverted mantle been used successfully for street lighting? If not, why not?

25. How do the results in street lighting with gasoline compare with those from lamps connected to the gas mains?

26. What is the best method of distributing light for a bowling alley?

27. How can the flickering of the electric arc be reduced so as to nullify its injurious effect on the eye when used for clerical work?

DISCUSSION.

Mr. John Campbell, Chairman.—There are perhaps some of these questions that are of more general interest than others. I will try to pick out questions of most general interest and value. I think, perhaps, Question 22 would be a very good one to start with: "What methods do con-

tractors generally pursue in locating either gas or electric lights on new work?"

Mr. N. W. Gifford.—I can say from my experience that perhaps this question has been handled in practice about as Newfoundland skippers are said to handle their vessels in the fog. They say,—"In the name of God, go ahead."

Mr. A. T. Sampson.—I am rather inclined to think that the last speaker closed the subject. The question of volume of light in certain rooms or certain areas to be covered varies so much with the colors and effects in general that it is rather a hard problem to state any particular method which we have adopted. It has been more a question of looking over the particular room or area to be covered and making practically a guess from experience as to what amount of light is necessary. Of course, in a show window we plan to do concealed lighting as much as possible—to throw the light as nearly as possible on the goods or on the area from the side at which it is to be looked at. In some cases where they are to be placed high, we light from below as well as from above. I am afraid I cannot give you any definite figures as to the amount of light for certain areas. I would like to hear from somebody else on this subject.

Dr. Louis Bell.—I want to say a word from the standpoint of the consulting engineer, in behalf of our much abused friend, the contractor, in dealing with questions of this sort. The expressions of opinion we have heard as to the way of going ahead may be taken half in jest and half in earnest; but the contractor is between the devil and the deep sea all the time. He has no specifications of value, because until within almost a few months the engineering side of this thing had not been to any extent taken up. The question of distribution of light from a scientific standpoint so as to give any basis whatever to go on except the intelligence of a solitary man, has not been dwelt upon, and it is a pretty hard situation. One of the things we should do is to straighten this out, for the contractor from the beginning of his work is between the burdensome rules of the underwriters, which compel him to do things in certain ways on the one hand, and on the other hand is continually up against the necessity for cheaper and cheaper work. The customer needs to be educated to the realization that there is such a thing as a superlative degree of light, and the contractor ought to be urged to go into it on that line instead of being asked to bid on a practically blank specification, the job to go to the lowest bidder. I do not think the contractor has had a fair show, either in the way of rules for proper lighting or for doing the work as his own skill would dictate, for he is all the time up against the idea that the building must be lighted for about half what should be the price for doing the work well. I think this is one of the objects of this Society—to get together with the contractor and help him out of that scrape. I am glad, for that reason, that we have some contractors with us.

Mr. G. R. Stetson.—I was very much impressed in reading, recently, a report of the New York meeting, with the fact that lighting had gotten to be an art—that we must have lighting engineers to study this subject and make it a specialty which will class with electrical engineering. In the first place, that engineer must have a thorough acquaintance with all kinds of lights that are to be used, and these are very numerous. He has also got to meet the tastes of his customers in regard to the colors of the different rooms to be lighted. In mansions such as are spoken of in the New York report, there is no limit to the desires of the owner for the elegant and finished product. Now that same owner desires different finishes in the different parts of the house, and the different shades of finish of the rooms make a very great difference in the amount, character and quality of the light you want to use, and all that has got to be specialized and standardized; therefore a lighting engineer becomes a necessity. I am satisfied that the practice of illuminating engineering can be erected on a scientific base and made a legitimate profession, and I believe there will ultimately have to be, as there are in New York and some other large cities now, men who will give their time to this subject and handle it as a specialty. That is entirely beyond the possibility of a man who is managing somewhat actively a good sized plant. He cannot study the kinds of light, colors or rooms, etc., which are factors in the proper solution of illumination questions, and at the same time attend to his business as an electrical engineer. There must be still further specialization, and that, I believe, implies a profession that is being now developed—an engineer who makes a study of light to obtain the best results—and from that study we can all receive the benefits. It is a scientific and intricate matter, involving interior finishes of various kinds, and a great number and character of lights, and also their different effects with respect to colors. So far as the general contractor now works along these lines, I presume he has two objects in view; one is to see what is the limit the employer will stand on the 10 per cent. basis on which he puts in all the lights, and the other is the best he can do with the amount of money available. That is the condition the engineer has to meet.

Chairman Campbell.—We will next take up Question 4, as being in line with the previous question. I think all the members of the New England section who have

sat through the meetings in this building realize that there are some possibilities in that line which have not been reached in this hall. Question 4 is now open for discussion. "To what extent can the rule for keeping lights out of the range of vision be followed in halls, churches, etc.?"

Mr. W. H. Gardiner, Jr.—I would like to call to the mind of those who were at the National Electric Light Convention, in Atlantic City, the unusually glaring lights in both the exhibition hall and the theater. The lights had unfrosted globes in the exhibition hall, studded all over a white ceiling. You could not get anywhere in the room without most of the globes in the ceiling staring you in the eyes. The ceiling was very low, and it was extremely trying in the auditorium where the meetings were held. There were a number of wooden arches, and each one was outlined in unfrosted lamps. There was also a horizontal line of lamps running down the building about 8 or 10 feet above the floor. I could not well conceive of a more trying scheme of illumination than existed there. In that case it would have been quite possible by very cheap shades to have screened the majority of those lights. In the ceiling lights, for instance, there was no demand for the artistic, and there would probably have been no objection to a simple tin shade of conical shape to throw the light from the ceiling lights down on the floor. The intense effect of the light then would have been mitigated and it would have been considerably above the line of normal vision. In the auditorium the light could have been thrown on the stage by reflectors such as are installed in the New York subway, where each motorman is protected from the direct light of incandescent lamps by having them shielded so that the light is thrown in the direction of the train. That is a thing I have not noticed in the Boston subway. It is a very good point, I think, in subway illumination.

Mr. W. W. Cummings.—I think this is the first evening that this chandelier here in the hall has not been lighted, and I think many of you who have been here have noticed at once the beneficial effect on the eyes in having that out rather than lighted. I have noticed this glaring effect in several cases, particularly in church lighting, and perhaps more particularly in Catholic churches, where the altar is supposed to have lights from artistic considerations rather than from necessity, and where many of them are so arranged as to form arches, outlined by incandescent lamps. I have one case in mind where the church was so illuminated, and there was a very depressing effect on the eyes of the people looking directly at these lights. Afterward these lights were taken out and replaced by larger units which threw the light directly under the altar and into the part of the church in the rear. The effect of the change was very good indeed. In the same church there were brackets, each with two incandescent lamps, neither shielded nor shaded, and the effect on the eyes of the people at the back of the church was very bad indeed. These were afterward changed to one single, larger incandescent lamp with a shade on the part facing the rear, throwing all the light toward the front. In that way the people got the light on the pulpit, which they needed; and, on the other hand, to a person in the rear of the church there was hardly any light perceptible save reflected light. The effect of the change was really remarkable. I think that in public speaking a great deal of supposed dulness of many speakers is perhaps due to the glaring effect of the light as much as to the speaker. There have been halls lighted in this city in which the light came from concealed lamps in the corners. I think Marston's restaurant is lignted that way on the principal floor. That goes to show, I think, that although illumination as an art is taking rapid strides now, it was not considered in the past. I think there is a large field for that kind of work in halls.

Mr. N. W. Gifford.—I have in mind a comparatively small hall—very low studded, not much over 11 feet—where an installation of unfrosted incandescent gas lamps was placed. There were four chandeliers of four arms each, with No. 2 burners, I think, and on the walls, two on each side, little lamps with quite heavily frosted globes. The color was very good for lighting in that the walls were a light yellow tint. The ceiling was white, and I am told that the lighting effect is very pleasant. It suits me very well to look at. The lights are sufficiently frosted that there is no objection to looking at them, as one would have to do in a hall of that kind and size.

Mr. H. E. Allen.—The auditorium of New York Edison Company, Twenty-seventh street, New York, is an example of working in the right direction, although it is not altogether perfect. The hall is lighted by means of incandescent lamps concealed around the walls, throwing the light on a semi-circular cornice. That presents a surface brightly lighted to the eye all the time. Then below those lamps the rest of the wall is dark, and anywhere you look around the room your eye is constantly meeting a brightly lighted surface and a less brightly lighted surface. It seems to me that some scheme like this on a high studded room would be very good. If you can shield the lights from sight and then throw the light on a reflecting surface and downward, you accomplish the desired object.

Dr. Bell.—In trying to light a space of

this character there are two methods available, each of which is capable of giving perfectly good results. In the first place, we can place the lamps very effectively indeed, but at a risk of localizing the light too much. A properly arranged cornice need not do this, but cornice lighting is not particularly efficient from the standpoint of energy. The other method is in the use of diffusing globes which are actually capable of cutting down the intrinsic brilliancy to a reasonable point. Almost nothing has been done so far in finding out the limitations within which one can go and still have a light which is all right for the eye. Almost nothing can be found. I said, about a year ago, that the outside limit was something like 5 candle-power per square inch. I think that limit is too high. The limit in this room is 10 candle-power, and they have deliberately put on frosted globes, but looking at any one of these little lamps you see that the intrinsic brilliancy is far in excess of any reasonable limit. If you look at the larger globes you will still see that this is true. The moral is that we want to get a globe which will actually cut down the intrinsic brilliancy per square inch to a reasonable extent and yet leave the light well diffused. That has not yet been produced in a globe which does not cut off a very large percentage of light. If one could get, for example, a globe the size of the larger globes used in this room, with a good distribution over the entire surface of the globe, you would have a radiant which will give very effective lighting indeed, and still could be tolerated in the range of vision; there are cases where you must put the light within the range of vision. That particular thing, a diffusing globe for cutting down the intrinsic brilliancy, has not, as far as I know, been introduced, and it is up to the men who make fixtures and globes to put a lot of study on that point so as to give us a light which will keep the intrinsic brilliancy down to about 3 candle-power per square inch and distribute that evenly over the globe. Given that, and this problem is capable of solution, because you can then put the radiant within the range of vision without hurting the eyes. The limits we have now, give a great deal more light than is necessary. I hope this will be done some time.

President L. B. Marks.—Just a few words in regard to a hall in New York City for which I designed the illuminating lay-out. I refer to the Gothic Chapel of the College of the City of New York, which is almost completed. This hall is roughly 150 feet long, 90 feet wide and 70 feet high, and will seat about 3,500 people. When the question of illumination was first discussed, it was thought that side lighting would offer the only practical means of getting a soft illumination along the working line—that is to say, about 2 feet 6 inches from the floor. Subsequently however, the following plan was adopted: Three clusters, each containing ninety-six 32-candle-power lamps, were mounted equally distant at 35 feet from the floor line. The lamps of these clusters were provided with suitable reflecting shades. In this connection I would say that it is, as you know, extremely important to select the proper reflecting shades. There is only one type of shade that I know of at the present time that will send the light down in two lobes—that is to say, divided equally on both sides in a wide room. This shade was selected for the particular purpose. None of the lights will be within the ordinary field of vision, and it has been figured that the illumination on the working plane will be approximately 1½ foot-candles, which is a very good reading light, particularly for a chapel of that kind. In order to introduce a softening effect in the illumination it was decided to install a number of side brackets (ornamental fixtures) along the side walls, these fixtures, however, being principally for decorative lighting. We are used to rooms which are illuminated by daylight from windows at the side, and therefore it is quite important in some cases to install side brackets to give side illumination, but great care should be taken when the lights are within the range of vision, as they usually are in such cases, to reduce the intrinsic brilliancy to a very low degree. For lighting the stage in the chapel, to which I have referred, an ordinary trough reflector will be used. The lights, of course, will be concealed from the view of those in the audience.

Mr. Allen.—I would like to ask the amount of energy in lighting up the church or the basis of the floor area.

Mr. Marks.—The total energy is slightly under 2 watts per square foot of floor space.

Mr. Sampson.—I would like to ask Mr. Marks the type of reflector that is used.

Mr. Marks.—In this particular case the Holophane reflector, Class B, was used. Naturally, considerable of the light goes up and illuminates the ceiling, which is an important matter. A dark ceiling is always to be avoided.

Mr. Sampson.—It seems to me that the lighting of a small hall, for instance, 12 feet or lower, is a problem, and I think that some scheme may be carried out of reflecting the light forward—that is, using some type of artistic fitting that will be shaded on the back and more open on the front, throwing the light toward the front. Of course, in this hall one of the particular objections is the mirrors right in the front of the room.

Chairman Campbell.—The next question is Question 1. "To what extent in practice can the distribution curve of a lamp

be modified, by shades or otherwise, to throw the light in certain directions?" In this connection I would say I received a communication from Mr. J. S. Codman, as follows:

"There is no doubt, whatever, that reflectors and even enclosing globes affect, to a very great extent, the distribution of light from light sources. We know this from careful tests made with photometric apparatus by experts, but it is also a simple matter to demonstrate it to our own satisfaction. A piece of white paper wrapped into conical form and placed in proper position relative to an incandescent electric lamp will more than double the tip candle-power, and it requires no photometric apparatus to make one feel sure of the truth of this, if the experiment is tried where extraneous light will not interfere. With first-class reflectors there is no difficulty in increasing the tip candle-power of a 16-candle-power lamp from 7 candle-power to over 100. Results of similar magnitude can be obtained equally well with other sources of light. For instance, the shadow of the burner thrown downward by an incandescent mantle can be completely obliterated by the use of a proper reflector, and, what is more remarkable, this can also be done by a globe of the right type, even though the source of light is entirely surrounded. Those who have not looked into the question may possibly have some doubt about the light increasing properties of reflectors, but it should be remembered that the increase is obtained only in certain directions at the expense of other directions, and that theoretically, if all the light from a source could be concentrated into a line of light, the candle-power in that one line would be infinitely great."

Mr. Cummings.—I think perhaps there is more to work on in the line of illuminating engineering in studying curves of lamps than in any other one thing. I do not know whether all are familiar with the curves of lamps. Of course, those of us who have studied the technical side know, but perhaps some here do not know. The curve of a lamp, we will say, is the curve formed by the candle-power as shown by photometric readings. The arc lamp gives two lobes of light having downward axes of about 45 degrees. It will be easily seen that the distribution is dependent in such a case on the height of the lamp. That is, an arc lamp within 6 feet of the floor would throw on the floor a circle of very brilliant light, and outside would be darkness. If you raise the lamp there is a certain point at which the illumination is very nearly uniform. Now, with the common 16-candle-power lamp the curves are very nearly horizontal each side of the light, and for that reason very little comes from the tip. I had occasion not very long ago to illuminate a dwelling house, and I hardly thought there was anything I could do to improve the old-fashioned way of using a few fixtures throwing the light in various directions. I did, however, by bringing the lamp up about 7 or 8 feet from the floor, and by the use of a shade, throw on an illuminated area, which was about the height of a table, light which was almost of uniform intensity. It is surprising what a different effect it has on the room. It gives a larger appearance. Again, on a wall bracket, by using another shade such as Mr. Sampson spoke of, light is thrown quite a distance from the center of the room. It can be perceptibly noticed that the shadow will follow the light by turning that shade around in a common arm bracket. The old "Meridian" lamp was a fairly good style of lamp to give uniform distribution on a small area. I think possibly that is the reason the gas arc-lamp gives very good results compared with the electric arc under certain conditions. The curve of a Welsbach lamp follows very closely that of the "Meridian" lamp. I think there is more in this matter than in any other thing concerning illuminating engineering.

Mr. Stetson.—A few years ago there was an effort made to light our cotton mills by the use of arc lights with reflectors from below, throwing the light up on the wall and reflecting it back again on the work below. We made some experiments in that line, and the effect was very pleasant, but the loss of light was more than the manufacturers wanted to stand. The light was diffused over the work and over the floor with very much the same uniformity you have in daylight. The brilliant light that was referred to was lost entirely and you could not see the arc light at all, but the light received from the reflector gave very pleasant results. It was too expensive, however, for general adoption. If there was anything further done in that line I would like to know of it.

Mr. Allen.—I would say that formerly we used a lamp with a reflector that threw the light on the ceiling, but unless we kept the ceiling perfectly white the amount of light was very small. Since that time they attached a reflector to the lamp and the light is reflected on the white surface and re-radiated. In cases where you do not care whether you have sharp shadows or not, the lower shade is done away with and the reflector is turned down to catch all the light that comes above the horizontal, which breaks up the shadows to some extent, but does not sacrifice the efficiency of the lamp.

Mr. Gardiner.—Mr. Stetson's remarks call to mind that in my experience the customer, and particularly public officials, are apt to consider altogether too much the quantity of light in their payments for

lighting rather than the quality of light. In a mill the manufacturer seems to think he is well lighted when his mill has brilliancy localized and does not consider the real effective lighting that he may get by properly reflecting or screened lights. The same thing applies in street lighting. You take the average Board of Aldermen out and show them a street that has an arc lamp at every block, and they think that street is well lighted because there are big bunches of light staring them in the eyes, and they would not consider paying the same price or a higher price for lighting that street uniformly throughout its whole length by lights of a lower candle-power. This is a practical question which seems to me involves a great deal of missionary work on the part of this Society in educating the public up to a practical appreciation of the quality rather than the quantity of light. What they are paying for is effective illumination and not localized candle-power. They seem to think if they get high candle-power they get the whole thing. Now, that to my mind is a very delusive standpoint. In the case of water gas versus coal gas, the public seem to think that if they get a high candle-power gas they get the whole thing. As a matter of fact, I think it is generally recognized that a lower candle-power coal gas is a better illuminant than a somewhat higher candle-power water gas. I think the ratio is set at 18-candle-power coal gas to 25-candle-power water gas for illuminating effect. To get the public to realize that it is the illuminating effect and not the candle-power they are really after, offers a line of missionary endeavor which, it seems to me, should be taken up by this Society.

Chairman Campbell.—We will next take up Question 23. "What objection could be raised to a street-lighting system whereby the lighting company would agree to furnish a certain number of light units per street mile?"

Mr. Smith.—I am somewhat interested in that subject, although it seems to me it is going to be difficult for some time to educate the ordinary politician we have in city government up to using so many units per street mile. It may be this Society can accomplish a good deal in that line, but it is hard work. They want an arc light in front of certain houses, and they do not care anything about units, watts or anything else.

Chairman Campbell.—I would like to add a word about politicians and street lighting, and direct attention to the influence the Society may exercise in the matter. Could not the Society educate the general public to demand from the politician certain things? It is true that there are certain people in town who will demand that their front lawns be lighted for them, and they usually seem to get it, but some other lawn is going without its fair share of light. Now, just as soon as the lighting companies, as a whole, and our Society, as a whole, get a little backbone and also assist a little in public education and show the people how much better are properly lighted streets—not a few lights lighting up some particular person's front porch and lawn—but an even distribution of the lights throughout the town, then we may have good street lighting. You ask the average central-station man what is the proper candle-power of incandescent lamps for street lighting work and the best distance apart for the lamps and see if he knows. The same applies equally well to arc lamps or gas lights for street lighting work. What right have we as engineers to expect anything different than we are getting from the public when there is not to-day practically twenty-five written words that are authoritative on street lighting work? How can we expect the public to demand any more than we demand? The fellow with the biggest pull now gets the largest amount of light, or there is a certain appropriation for lighting and you can only go so far with that and no further. Is it not a question of educating the general public to the fact that they should so divide their appropriation that the whole town will receive a fair share and benefit from the lighting appropriation? Then the whole town will rise up and demand more light where it is needed.

Mr. Gardiner.—Some two or three months ago I had occasion to appear before a Board of Trade of a town near Boston regarding the renewal of a contract with the electric light company which does the most business around here, and in the discussion of the renewal of the contract, which involved a change in price on a five years' contract amounting to several thousand dollars a year, they seemed to be absolutely at sea on the subject of lighting their streets. Now, lighting streets falls in my mind into two classes. There is street indication by lights and street or road illumination. This was a suburban town sparsely settled, and I recommended to them not to decrease the mileage of light and localize it by means of arc lamps or high candle-power incandescents, but maintain the same mileage of street indicated by lights. In the case of the ordinary street there is no attempt at lighting proper; the location of the street is indicated and there is a dull glow so that people in driving and walking will not get off the street. Then comes the illumination of more densely settled districts which is a different class of street lighting. I think the chairman's remarks as to the propriety of having all the streets what I call indicated by lamps is correct, and then the public will demand, first, the illumination of the prominent streets, and then the extension

of it into the suburbs and more sparsely settled streets. I think these are the proper lines of street illumination for the public and the lighting companies to work along. The question is one, I think, open to a good deal of discussion, for I think a specification setting merely a number of light units per street mile would have to be very carefully drawn. I think the unit should be much smaller than the street mile. If a Board of Aldermen tells a lighting company that it wants so many thousand light units per mile, the immediate temptation from a dollars and cents point of view of the company is to centralize its light in such form as will give the specified number of light units per mile of street in the most economical form to the company. I think the specification should be very carefully drawn so that a proper distribution of light over each mile of street should be given. My idea of street lighting is a uniform lighting, the quantity of the illumination increasing as the importance of the street increases.

Mr. J. W. Cowles.—I think Mr. Gardiner's remarks in regard to street indication and street illumination are very apt. We certainly have two distinct classes to deal with—street illumination as we see it in streets and blocks in the city proper, where we must have a brilliant illumination such as is obtained from the arc light; then as we go out from the thoroughfares into the more suburban districts we encounter different conditions. Those of us who have occasion to ride evenings know how much more satisfactory it is to follow a street with a uniform lighting of small units frequently placed than with large units such as arc lights more infrequently placed. The matter of trying to talk to a City Council or Board of Aldermen on the basis of light units per street mile seems to me quite out of the question and altogether irrational, considering the varying conditions of the streets, and the surrounding territory, foliage, etc.

Chairman Campbell.—As to the question of candle-power in street lighting, I do not think there is anything as misleading as the term candle-power used in that connection. It is not a question of candle-power. Your lamp candle-power may be anything. It is not a question of candle-power of the lamp as much as it is of a distribution and getting down to a proper unit of illumination.

Mr. Gardiner.—I should like to add a word in accord with what the President has just said about candle-power. I had another occasion where I struggled with the selectmen in another town that was renewing its contract with another electric light company, and they insisted on figuring the thing on the basis of so many total thousand candle-power per so many total thousand dollars per annum. If they could get more candle-power for a dollar out of arc lamps, they would go in for arc lamps. It was an absolutely foolish line of argument, and yet one for which illuminating engineering, as practiced in the past, is directly responsible. We have always talked candle-power as the illumination unit, and the public is not to blame for talking it. They said they could get so many hundred arc lamps of 2,000 candle-power for so much money, and they could get so many hundred incandescent lamps for so much money. Well, they could get more candle-power from the arc lamps and they were for the arc lamp.

Mr. Sampson.—My experience has been that about the worst source we can have is an arc lamp placed directly over the street and very low. In approaching the light you can see hardly anything until you get under the light. Lights placed a little back from the street will give better lighting than right in the line of travel. You can see by the light then, it is not directly in the line of vision. I am strongly in favor of small units distributed along the side of the road.

President Marks.—I should like to add, that if you are going to specify foot-candles on the street, you will have to go one step further and state whether you mean foot-candles on a plane normal to the incident ray or otherwise. The foot-candles would vary as the cosine of the angle of illumination.

Mr. Gardiner.—I think it would be hard for them to grasp the full meaning of the intent of specifications made, not in terms of so many arc lamps, but of so many foot-candles on a plane normal to the incident ray.

Dr. Bell.—It seems to me that the illumination foot-candle is, after all, the thing we are after. The question is really, what is the minimum light on the street that shall be tolerated measured in foot-candles? When we wish to specify a certain illumination and how it shall be measured, it seems to me that a fair way to do it is to count the illumination as on a substantially normal plane or surface from one direction only. What you wish to see on the street if you are riding at night is the elusive brickbat that is apt to come under your tire. The light which comes from the other direction does not interest you in the least. It may and does double the working illumination on the surface, but the illumination on your side of the brickbat is what counts.

President Marks.—In England they look at this from a different standpoint. I am inclined to think some of our British friends would take exception to what Dr. Bell has said on that point.

Mr. T. R. Robinson.—I think there is a commercial factor in this question which has not been brought out. The lighting company is always looking for the money it can obtain from its service, and by agreeing to furnish a certain number of lamps per mile it assures itself of a certain amount of

revenue. I have found it is better to put the number of lights which can be placed when extending the service, on the basis of a certain number of feet, from the fact that the selectmen or officials of a town desire to extend their lights to cover as great a surface as possible and without any idea as to the illuminating value of the lamp. They think 600 feet is a proper figure, when 300 is about all the light can cover; placing a limit of 300 or 400 feet for each lamp would cover the commercial side and yet result in a fairly good street lighting service.

Mr. Stetson.—As an illustration of the political aspect of this illumination for streets, I would say that in a city I am acquainted with, the outgoing administration put in all the lights possible during the last six weeks of their term of office. The incoming administration wanted to show the great economy that was being exercised and took them all out again. The new demand for well-lighted streets and the automobile may have the effect of correcting errors in the matter of lighting as it has in the character of the streets. We may have better streets and better lighted streets. There is no question that the illumination of the old high candle-power open arc lamp has been properly sidetracked for the enclosed lamp. With the former you get such brilliant light that it blinds you when you are going towards it and puts your eyes out in trying to get away from it. That is one of the transitions that has come about through the education of the people. Now, whether there is to be another transition that will result in the light being more generally distributed is a question.

Chairman Campbell.—The next topic for discussion is that of Question 21. "What would you suggest as the most practical means of increasing the efficiency of modern illumination?"

Mr. Gardiner.—The suggestion which occurs to me off-hand is first to use the proper illuminants, the proper units, and, second, to place them properly.

Mr. Cowles.—May I not add to that a third—the use of proper shades?

Chairman Campbell.—We will next take up Question 11. "Where interior illumination is used for selecting or matching colors, etc., what is the best method of determining the suitability of the illuminant used, and wherein it is defective for the particular work in hand?"

Mr. Gardiner.—Speaking rather as a layman in this matter, it would seem to me that the natural course in choosing an illuminant for matching colors would be to select one, the spectroscopic analysis of which is as close to reflected daylight as possible. I am aware that the artificial illuminant which gives the nearest spectroscopic analysis to daylight does not sometimes give corresponding results in matching colors, but off-hand that would seem to be the natural course in selecting light to match colors.

Mr. Stetson.—In the discussion in New York they agreed on this so far as to say that the proper arrangement in a store furnishing materials for dress goods, should be rooms so lighted that a lady could tell whether a dress would look well under an electric light at a ball or whether it would be proper for a funeral. I suppose that is the idea, and that seems to have sense in it. You cannot get any one light that will act pleasantly on all shades of colors.

Mr. Allen.—I think the last speaker has covered the question pretty well, but it seems to me the light that comes the nearest for all colors is the one coming nearest to daylight. By using opal shades the blue can be filtered out.

Chairman Campbell.—I think we will next take up Questions 5, 6 and 18, and discuss them together. They are as follows: Question 5—"Is there any standard that can be used in the selection of Welsbach mantles?" Question 6—"What is the best economy with Welsbach mantles—to purchase a high-grade mantle and use it until it breaks, or purchase several cheaper grades for use the same length of time as the one of high-grade quality?" Question 18—"What is the effect on the light and life of a Welsbach mantle due to a change in the gas pressure?"

Mr. J. F. Wing.—Referring to Question 6, people do not always have any better success with a high cost mantle. With the little experience I have had I think the high cost mantle is more reliable, stronger and more lasting, and the satisfaction obtained from it is altogether out of proportion to the money paid for it.

Mr. Gifford.—More pressure tends to increased efficiency, and changing pressures would naturally tend to disintegration; so in a general way in a Welsbach light you want a constant pressure.

Mr. Sampson.—To increase the pressure is to increase the gas flow, and unless you can keep a mixture uniform, you will get the blackening effect. Our experience has been that the best mantle is the cheapest in the end, and is one in which the weave gives a certain strength to stand vibration. The commercial problem is to get a mantle which will give good illumination and still not break and crack. We find a light mantle is very apt to break where pressure is high. Sometimes those that work and give good results in the daytime, give poor results after the high pressure goes on at night.

Papers Read Before Technical Societies

COLOR PHENOMENA IN PHOTOMETRY

By J. S. Dow, B.Sc.

Read before the Physical Society (English), May 25, 1906.

The discussion of Dr. Fleming's Paper on Photometry, read before the Institution of Electrical Engineers in 1903, revealed great differences of opinion on the importance of color phenomena in photometry, and it still does not seem to be generally known to what extent they are noticeable under ordinary working conditions. This may be due to the fact that most of the work done on this subject was carried out with special apparatus, such as the spectrophotometer, and not with the ordinary implements of photometry.

It therefore occurred to the author that some simple experiments on these points, carried out by him at the Central Technical College on an ordinary photometrical bench, might be of interest.

The sources of light were two similar glow lamps, which could be screened with glass of different colors, and which were compared by means of one or other of several different photometers in the usual way. Four photometers were made use of during the experiments—the Lummer-Brodhun, the grease-spot, the Joly, and the Flicker.

The uncertainties which may be introduced by color phenomena appear to be due to four separate effects:—

1. The difficulty experienced in forming a judgment in the case of differently-colored lights, and the possibility that the judgments of different people may not be the same.

2. The fact that the apparent relative brightness of two surfaces, illuminated by light of different color, depends on the part of the retina on which the image of them is received.

3. The Purkinje phenomena.

4. The possibility, when mirrors are made use of, that the coefficient of reflexion may not be the same for different colored lights.

1. No doubt people differ in their capacity in this respect, but according to the author's experience it is chiefly a matter of practice. After a considerable amount of practice, he has found that it is possible to secure fairly consistent results even when comparing such colors as ruby-red and signal-green, while anyone unused to such work would be quite unable to do so. Extraordinarily consistent results were sometimes obtained, but it was found that if the observer stopped work for an hour or so, his readings afterwards would settle down to another very consistent value, but differing by, perhaps, 5 or even 10 per cent. or so from those obtained before. This seems to suggest that extreme consistency in reading is partly a matter of visual memory. We recall the impression previously received by the eye and involuntarily set the photometer, the next time, so as to produce the same appearance of the field of view.

The difference in sensibility of different eyes to a particular color certainly introduces another disturbing factor in observations made by different people. The author has not met with any serious differences in judging the color contrasts which ordinarily occur, but it might be supposed that, in such an extreme case as that quoted above, considerable divergences in judgment would exist, and have, indeed, been recorded by Sir Wm. Abney, Prof. Rood and others.

It must be noted, however, that the effect mentioned in (2) must be eliminated, in order to make any satisfactory comparisons. All the figures given in this paper were obtained by the author himself, though corroborative results from other eyes were obtained in many cases.

2. This effect has been very completely dealt with by Sir William Abney in his investigation on color vision.

It has long been known that the central portion of the retina—"the yellow spot"—is much more sensitive to the red end, and less sensitive to the blue end of the spectrum, than the surrounding portion of the retina.

It has been suggested that the "yellow spot," being yellow in color, will obstruct the blue rays, but will allow the yellow rays to pass through practically unimpeded to the light-perceiving organs. This explanation, however, does not explain why the differences observed are distinctly more noticeable at low illuminations.

There appears to be another physiological effect, which will be referred to later.

Suppose, now, that we compare a red and a green light with a Joly photometer. An image of the illuminated blocks is formed on the retina, and we adjust the position of the photometer until the red and green appear equally bright.

But if we now observe the photometer obliquely, or if we observe it with the eye at a different distance away, the image falls on a different part of the retina where the sensibility to red and green may be different. Consequently the red and green may no longer appear equally bright.

And if a photometer with blocks of a

different size were used we might again come to a different conclusion; for, even if the eye were kept at the same distance, the size of the image would be different, and a new portion of the retina would be covered by it.

The position of the photometer, for which we obtain balance, therefore depends upon—

(*a*) The obliquity at which rays from the illuminated surface strike the eye.

(*b*) The distance away of the eye from the surface.

(*c*) The size of the surfaces.

The first point is not very important, for in focusing our eyes on the surfaces we involuntarily look straight at them. But (*b*) and (*c*) may easily affect the readings considerably. This is brought out in the curves in Fig. 1.

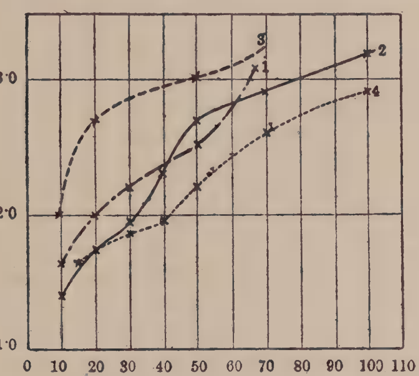


FIG. 1.—RUBY-RED LIGHT COMPARED WITH SIGNAL-GREEN.

(1) Lummer-Brodhun Photometer (telescope removed). (2) Joly Photometer. (3) Joly Photometer (linear dimensions of blocks reduced by half). (4) Grease-spot Photometer.

These curves were obtained as follows: Two glow lamps, screened with red and green glass respectively, were run at a constant P.D., and compared by means of each of the three photometers referred to above.

In each case a series of readings was obtained with the eye at different distances away from the illuminated surfaces. It should be mentioned that in the case of the Lummer-Brodhun photometer, the telescope was removed while the readings were taken. As will appear later, however, considerable variation is possible even with the telescope in position, as in use.

Curves (1), (2) and (3) speak for themselves. They bring out two points. Firstly, that the ratio of the candle-powers of the red and green lights, as thus observed, is quite different for each photometer. Secondly, that this ratio depends on the distance of the eye from the photometer, the red becoming more and more accentuated as the eye recedes. Also the red is most accentuated and the curve is steepest for the Lummer-Brodhun photometer, in which the field is smallest.

Curve (4) was obtained by placing in front of the blocks of the Joly photometer a paper screen which reduced its linear dimensions by one-half. The reduction in size of the blocks corresponds with a still further accentuation of the red.

This effect has been found to be quite distinctly observable in several commonly occurring comparisons. Fig. 2 exhibits the connection between the apparent relative candle-power and the distance away of the eye with a Joly photometer, when a Nernst lamp was compared with a glow lamp (running at 3.7 watts per candle-power), and when an incandescent mantle was compared with a Methven burner.

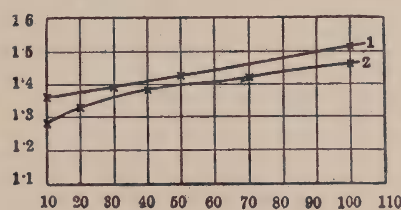


FIG. 2.—CURVES FOR JOLY PHOTOMETER.

In the Joly photometer the distance away of the eye is left entirely to the inclination of the observer, and it will be seen from the above that differences of 5 per cent. or more might easily be introduced between the readings of different observers in this way.

(1) Glow Lamp compared with Nernst Lamp. (2) Methven Gas Standard compared with Incandescent Mantle.

Nature of lights compared.	Ratio of candle-power. Telescope in.	Telescope out.	Percentage difference.
Ruby-red to signal-green................	1.65	2.20	25.0
Glow lamp (3.7 watts per candle-power) to Nernst lamp	1.38	1.43	3.5
Methven gas standard to incandescent mantle	0.129	0.135	4.4
Harcourt 10 c. p. Pentane standard to Fleming standard glow lamp.........	0.652	0.657	0.77

In the Lummer-Brodhun photometer the distance of the eye is limited, to some extent, by the use of the telescope. But the position of the telescope can be varied between wide limits without putting the field out of focus, and this latitude allows of a considerable difference in the readings.

In the table on the opposite page the extreme differences are given for these two limiting positions of the telescope.

Here, again, a distinct difference in reading is produced in several practical cases.

It is also remarkable that a small but distinct effect was produced in the last case, even though the flame of the Harcourt lamp is only very slightly redder to the eye than the light from the Fleming glow lamp.

It is difficult, of course, to speak with certainty of such a small change as this—a change which would be produced by moving a photometer, set midway between two lights 2 meters apart, a distance of less than 2 mm. But the writer has usually found that the mean of a set of readings, taken with the telescope out, worked out to a value slightly different to the mean of those taken with the telescope in, and the difference was always in favor of the redder of the two lights. It need hardly be said that the difference observed might be important in such work as these two standards are used for.

There is one other point that requires mention. It is, of course, often necessary to reverse a photometer in order to correct for any differences between the two sides of the screen, etc. However, for lights of similar color, very little difference is produced by doing so, as a rule.

But when the lights differ in color the Lummer-Brodhun behaves differently from the Joly and grease-spot photometers. In the case of the latter, the image the retina receives is unaltered by reversing. But, with the Lummer-Brodhun, the image is reversed. If, before reversing, we see a green disk with a red center, after reversing we see a red disk with a green center.

We should, therefore, expect a much greater difference on reversing the photometer in the case of the Lummer-Brodhun.

The figures given in the table below were obtained for similarly colored lights, and for red and green lights.

3. The Purkinje phenomenon has often been referred to as the chief source of trouble in heterochromatic photometry, but it appears to be only troublesome at very low illuminations.

An experiment was shown illustrating the Purkinje effect. A series of colored screens, diminishing in size from about 4 ft. square, as shown in the diagram (Fig. 3), were illuminated by a 32 c.p. glow lamp at a distance of about 10 ft. away. All these screens were made from the same identical red and blue paper, but, even at normal illuminations, it could be seen that as the surfaces became smaller the red appeared brighter and brighter in comparison with the blue. The red, however, was distinctly the brighter, even in the case of the very large screen.

The illumination was now weakened by introducing resistance in series with the glow lamp, and the blue began to appear brighter. A point was soon reached when, for the very large screen, the blue was unquestionably brighter than the red. At this stage the difference in appearance of the different-sized screens was much more marked than at the higher illumination, and, in the case of the smaller screens, the red was still much brighter than the blue.

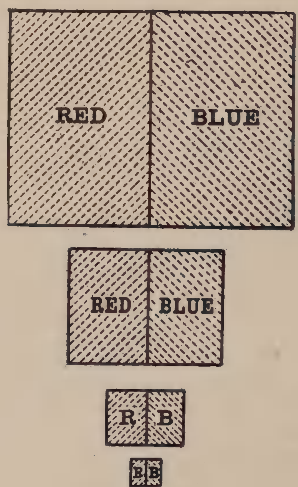


Fig. 3.

As the light was still further weakened the colors began to disappear until, eventually, the red appeared as black, while the blue shone out with a phosphorescent white appearance. After this point the blue also fades away until nothing can be seen.

There is, however, a distinct difference between the behavior of the very big screen and the very small ones. In the case of the latter the Purkinje effect is much weaker. Both colors seem to fade

Photometers used.	Lights of similar color. Ratio of C.P. 1st pos.	2nd pos.	Per cent. differ.	Red to green light. Ratio of C.P. 1st pos.	2nd pos.	Per cent. differ.
Joly	0.93	0.91	2	2.24	2.12	5.5
Grease-spot	0.94	0.91	3	1.81	1.70	6.0
Lummer-Brodhun.	0.95	0.91	4	2.10	1.75	18.0

away together, and, by the time the Purkinje effect is really noticeable on the big screen, the very small screen can scarcely be seen at all.

In fact, to see the Purkinje effect really well, it is necessary to stand quite close up even to the big field.

A very interesting physiological explanation of these effects has been given by M. Sartori in a recent paper.*

Dotted about over the retina are two varieties of light-perceiving organs, known from their appearance as the "rods" and the "cones" respectively. The rods, it is thought, are sensitive to light, but cannot perceive color. Light of any color appears to them white, but they are most sensitive to blue light. They are, moreover, sensitive to very weak light; but as the illumination is increased they become, as it were, saturated, and do not respond any further. The cones, on the other hand, perceive color, but are most sensitive to yellow-green light, and while they do not respond at the low illuminations at which the rods can act, they continue to respond further to increased stimulus, once they have started, long after the rods have ceased to do so.

At normal illuminations, therefore, it is the cones which chiefly act, and we see color. At very low illuminations the action of the rods is predominant, and we cannot see color, while light of a bluish color shines out with a whitish appearance. As the illumination is increased the cones suddenly begin to act and the colors appear. Then takes place what has been called "The Battle of the Rods and Cones." It is while this battle is in progress that the Purkinje effect is noticeable.

But the Purkinje effect is complicated by the fact that the rods and cones are unequally distributed over the retina. At the yellow spot the cones are predominant. Consequently, the Purkinje effect is much weaker when the field of view subtends a small angle at the eye.

This uneven distribution of the rods and cones will also explain the fact, referred to above, that at low illuminations, the size of the field of view can produce much greater differences in the results.

In order to gain an idea at what illumination the effect becomes noticeable in practice, the following experiment was carried out:—

Two 100 volt 8 c.p. glow lamps were run in series with a constant P.D. of 190 volts across them.

One was screened with red glass and the other with green glass. The distance between the two lamps was varied from 20 in. to 250 in., and the mean of a set of readings, giving their relative candle-power, taken in each case. In order to avoid the effect mentioned in (2) above, the Lummer-Brodhun photometer was used, and the telescope was kept in exactly the same position throughout the experiment.

Fig. 4 shows the result of plotting the ratio of the candle-power of the two lamps

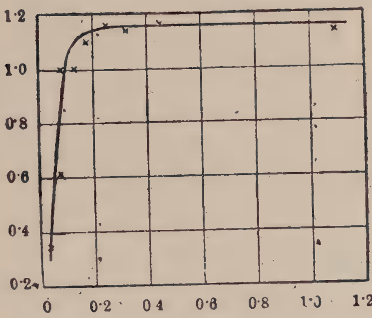


FIG. 4.—CURVE EXHIBITING PURKINJE PHENOMENA FOR RUBY-RED AND SIGNAL-GREEN LIGHTS.

against the illumination of the photometer disk, in candle-meters.

From what has been said above, it is clear that we cannot, strictly, define the candle-power of a red light in terms of white-light standard, because this ratio depends upon the distance of the eye from illuminated surfaces.

Nevertheless, in order to give an idea of the order of illumination used, the red lamp was compared against a 2 c.p. Methven gas standard, using the Lummer-Brodhun photometer, and its candle-power worked out to something of the order of 0.25 c.p.

The relative illuminations used in the curve are expressed in terms of this figure.

It will be seen it is only when the illumination has been reduced to about 0.2 candle-meter that the ratio of the red to the green light begins to decrease.

The same experiment was tried on several occasions with lights of different candle-power, and it was always found that fairly consistent results were obtained until the illumination fell to something of the order specified above, when the accentuation of the green light began to appear.

At such illuminations it is very difficult to obtain readings at all, and the mean of a great many should be taken. The eye seems to be in a state of uncertainty, and one receives the impression that the lights are continually varying. In fact, the eye seems to be in a state analogous with that of unsaturated iron on the steep part of the magnetization curve.

It may safely be assumed, therefore, that in all ordinary cases, where the illumination would be at least 10 or 12 times as great as that employed above, where the

* *Elektrotechnich und Maschinenbau,* March 18, 1906.

field of view would subtend a comparatively small angle at the eye, and where we should never meet with such an extreme color contrast as in this case, the Purkinje phenomena will not materially influence the results.

4. In order to obtain the curve of vertical distribution of light from arc lamps, etc., the beam of light is often reflected in the desired direction by means of a 45 degrees mirror.* When this is done, the question arises, whether the coefficient of reflection of the mirror will be the same for lights of different color.

The following experiment was carried out with a silvered glass mirror of this type: Two 200 volt 32 c.p. lamps were run in parallel off a constant P.D. of 200 volts. The two lamps were compared against each other direct. They were then compared when the light from one of them was reflected along the bench from the mirror. In this way, the coefficient of reflection of the mirror is easily obtained.

This was repeated when the lamps were screened with red and green glass, successively.

The mean of one set of determinations gave—

Coefficient of reflection, 78.8 per cent. for unscreened lamps.

Coefficient of reflection, 79.0 per cent for red light.

Coefficient of reflection, 77.8 per cent. for green light.

Repetitions of the experiment gave slightly differing results, but it was found that the values for the three different colors did not differ among themselves by more than 2.5 per cent. Moreover, no connection could be traced between these differences and the colors, for the difference was sometimes in favor of the red light and sometimes in favor of the green.

We may safely conclude, therefore, that in all ordinary cases, where the difference in color is less pronounced than that adopted here, the effect is inappreciable.

In any case, the adoption of adjustable photometers of the Simmance-Abady type will probably render mirrors unnecessary in obtaining curves of distribution of light in the future.

The only really important effect, under ordinary working conditions, therefore, is that described under the second heading. It has been shown that this may, apparently, give rise to a perceptible discrepancy even when lights so similar in color as the Harcourt 10-candle Pentane standard and the Fleming glow lamp standard are compared.

FLICKER PHOTOMETERS.

The interesting question now arises whether photometers of the Flicker type are also influenced by these color phenomena.

* A mirror, that is, which rotates about an axis making an angle of 45 deg. with its plane.

If, as is claimed, the disappearance indicates that the two surfaces appear equally illuminated to the eye, one would suppose that all the conditions which determine this impression must also determine the point of disappearance of the flicker. On the other hand, Mr. T. C. Porter and others have come to the conclusion that the flicker, at ordinary illuminations, is independent of color.

Through the kindness of Messrs. Everett, Edgcumbe & Co. the author has been able to make some experiments on the points referred to, with a photometer of this kind.

It is clear, in the first place, that when comparing lights of different color, the readings of an ordinary photometer and a Flicker photometer may not agree even if the latter be independent of all color effects. For instance, when two lamps giving light of exactly the same color were compared, the results with the Joly photometer and the Flicker photometer were exactly the same. The two lamps were now screened with red and green glass respectively, and the ratio of the red to the green, obtained by the Flicker photometer, was about 1.34; but with the Joly photometer it was found possible to get readings from 0.7 to 1.4 for distances of the eye up to ½ meter. Agreement between the photometers occurred when the eye was about 40 cm. away from the blocks of the Joly.

One difficulty met with in this investigation was as follows: As the effects observed were comparatively small, it was advisable to use lights widely differing in color. On the other hand, the position of minimum flicker, though sufficiently sharply defined in most practical cases, is far from being so when such colors as red and green are observed. In such cases, the method followed was to note the position of the photometer in which a flicker was just visible on either side of balance, and take the mean. There is, however, another method of judging the position of balance for these two colors.

When the photometer is too near the red light, the field of view in the photometer appears reddish in tint. Similarly, a greenish tinge shows that the green illumination is the stronger. When the illumination of the two surfaces, illuminated by light of these two complementary colors, is the same, an intermediate grayish tinge is produced. To the writer's eye the transition from red to gray to green was sharper than the disappearance of the flicker, and a series of tests showed that the result was the same in each case. The method, however, is only applicable to complementary colors.

Some experiments were first made to discover whether a difference of reading could be produced by altering the telescope, as in the case of the Lummer-Brodhun

photometer, but no distinct difference was observable. Next the telescope was removed, and readings were taken with the eye about 20 cm. from the aperture. A brass tube was then inserted which allowed the aperture to be inspected from a distance of 60 cm. from the eye. It was then observed that, as the eye was withdrawn, the field became distinctly redder, and readings taken by the "disappearance of flicker" method also showed a change of relative candle-power in favor of the red. The following table exhibits some of the results obtained:—

The plan of "color-reading" referred to above was therefore adopted. It may be objected that in doing so the real question at issue is avoided altogether. But the method, while admittedly not so satisfactory as the "disappearance of flicker" method from this point of view, has been shown to give the same results at ordinary illuminations, and to the writer it seems impossible that the green illumination could be brighter and yet the field of view appear red.

Two 100 volt 8 c.p. lamps screened with red and green glass in the usual manner were used for the experiments. They were first run at 100 volts, and compared against each other at different distances. The two lamps were then run off 50 volts only, so as to produce a very low illumination, and the experiment repeated. The following table shows very clearly the influence of the Purkinje effect.

Nature of lights compared.	Eye 20 cm. from aperture.	Eye 60 cm. from aperture.	Percentage change.
Ruby-red to signal-green................	$\frac{\text{Red}}{\text{Green}} = 1.52$	$\frac{\text{Red}}{\text{Green}} = 1.70$	12
Ruby-red to light from unscreened glow lamp (white)	$\frac{\text{Red}}{\text{White}} = 0.70$	$\frac{\text{Red}}{\text{White}} = 0.75$	6
Methven gas standard to incandescent mantle	$\frac{\text{Methv.}}{\text{Inc.}} = 0.28$	$\frac{\text{Methv.}}{\text{Inc.}} = 0.29$	3

The effect is very noticeable when observed in the following way: Supposing we are comparing red and green, and have placed the photometer so as to secure balance. Move the photometer until a distinct flicker can just be seen owing to the green being too bright. It will be found that as the eye is removed the flicker gradually disappears. But if the photometer is put out of balance on the red side, the flicker does not disappear, but becomes, if anything, more distinct as the eye is removed.

It appears, therefore, that this Flicker photometer is affected by the distance of the eye, but, apparently, not to a sufficient extent to be noticeable when the telescope is used, as in ordinary work.

It is difficult to see why these effects should be so much less noticeable than with ordinary photometers. It almost seems as though, when two differently colored objects are placed side by side, any change in their relative illumination becomes exaggerated, thus creating a different impression to that received when they are viewed alternately (as in a Flicker photometer).

An attempt was also made to discover whether the Flicker photometer was subject to the Purkinje phenomenon. Now, it is well known that the speed required to just make the flicker disappear depends upon the illumination, and the writer has found it impossible to judge the point of disappearance of the flicker with any certainty at the extremely weak illuminations necessary to produce the Purkinje effect.

Lamps run at 100 volts.

Distance between lamps.	Ratio $\frac{\text{red}}{\text{green}}$.
50 in.	2.32
60 in.	2.26
70 in.	2.25
120 in.	2.15
150 in.	2.25

Lamps run at 50 volts.

Distance between lamps.	Ratio $\frac{\text{red}}{\text{green}}$.
40 in.	2.0
50 in.	1.5
60 in.	1.1
70 in.	0.7
90 in.	0.6

At the higher illumination the readings differed among themselves considerably (as was only to be expected with such a great color contrast), but they do not seem to be connected in any way with the illumination.

The readings at the low illumination can only be regarded as very approximate, but they bring out very clearly the accentuation of the green as the illumination gets weaker.

The conclusion the writer draws from these experiments is that Flicker photometers are affected by the same color phenomena which affect ordinary photometers.

The interesting assertion was made by Messrs. Simmance and Abady, in a Paper before the Physical Society,* that a color-blind person obtained practically the same results with their Flicker photometer as people with normal sight. On the other hand, Sir Wm. Abney, speaking of color-blindness, remarks:—†

"We cannot hope, for instance, that the red-blind, who sees no red in the extreme end of the spectrum, would show any luminosity in that region. . . . One of the most striking experiments in color-vision is to place a bright-red patch on the screen and to ask a red-blind to make a match in luminosity with the white. The latter will have to be reduced to almost darkness —a darkness, indeed, that makes the match almost incredible."

It seems incredible that such a person, when comparing red and green with a Flicker photometer, would obtain the same results as if he had normal sight. However, it appears that, according to Dr. Edridge Green,§ color-blindness is of two kinds. A person may be unable to distinguish, say, red light by color, but nevertheless a red object may appear as *luminous* to him as to anyone else. On the other hand, the color-blindness may be due to the fact that the eye is incapable of perceiving red light at all. A color-blind person of the first variety would presumably make normal photometrical readings. A person of the second class must, surely, obtain abnormal readings with all photometers, Flicker or otherwise.

This is borne out by some of Prof. O. N. Rood's experiments on flicker.|| He found that those of his students who were color-blind obtained abnormal results with his Flicker photometer. Indeed, he actually used the Flicker photometer to investigate not only cases of color-blindness, but also the difference in sensibility to light of different colors of the eyes of persons with normal sight.

In conclusion, the writer wishes to express his great indebtedness to Prof. Ayrton, and also to Mr. J. M. McEwan, for their assistance and for many valuable suggestions.

* *Phil. Mag.*, VII., p. 341 (1904).
† "Color Vision," p. 83.
§ "The Physical Aspects of a Theory of Color Vision," by F. W. Edridge Green, M.D., British Association, 1902.
|| *American Journal of Science*, 1899, p. 258.

RADIATION FROM INCANDESCENT MANTLES

By J. Swinburne.

Read beforse the British Association.

The ordinary explanation of the great luminous efficiency of the gas-mantle is that rare earths have a property of selective radiation, in virtue of which they send out a larger proportion of their radiant energy in the form of light than ordinary hot bodies. The rare earths also suffer from "luminescence," which may be a disease on its own account, or a symptom of catalysis, or polarization, or something. Another explanation, first given, I believe, by Ram ("Incandescent Lamp," p. 196), is that the bunsen flame is really very hot, and that the mantle is of such low emissivity that it gets rid of so little power that there is slight difference of temperature between it and the flame, and it is therefore hot enough to give the light by pure temperature radiation without any anomaly.

One reason why the simple temperature explanation has been much questioned, and generally rejected, is that the temperature of the bunsen flame is generally taken to be much lower than it is. It is generally measured by means of platinum wires or thermo-couples. These can never rise to the real temperature of the flame, as they are radiating, and must therefore be taking in heat by conduction, in which case they must be cooler than their surroundings. The simple temperature explanation fits the phenomena. If pure thoria has low emissivity, it will rise to a temperature near that of the shell of flame bathing it. Having low emissivity, it will then give out light; but the light will have a larger proportion of visible and refrangible rays. If a very little of a body with a high emissivity be added, radiation will increase, but the temperature of the mantle will fall, as there must be a steeper heat-gradient to supply it. The total radiation is then increased; and though the proportion which is luminous will be diminished, the total light will be augmented. Further addition of the emissive substance increases the total radiation and reduces the temperature until the light given is less even than with pure thoria.

It may be urged against this that thoria, zirconia, and alumina, for example, are white, and therefore may be expected to have little luminosity when hot, as a white body, being a good reflector, should be a bad emitter. But ceria, if pure, is also white, about as white as thoria, and therefore should have the same order of emissivity as thoria. Adding 1½ per cent. of it cannot, therefore, increase the emissivity of the mantle very much. But it does not follow that a body which is white when cold necessarily remains white when hot.

Zinc oxide, for instance, gets yellow when hot, and ceria may emit like a dark colored body when hot. According to Féry, it has a much greater emissivity both for heat and light than thoria. The ceria of chemistry books is white, but the ceria of commerce is yellow.

Almost anything colored, however, increases the light of thoria if added in very small quantities. The reason why ceria is used is not that it has any peculiar radiating qualities. It is chosen because it is fairly permanent at the high temperatures, and does not weaken or spoil the thoria mantle. The earlier mantles were of zirconia and yttria, in the proportion to make a normal zirconate. Zirconia alone gives very little light, and makes a bad mantle mechanically. The yttria would contain erbia if separted by potassium sulphate. When lanthana was used, it would probably contain didymia, and prehaps ceria.

The light of the mantle may thus be purely that due to a hot body at a given temperature; the proportion of components of different frequencies being simply that due to the temperature. The addition of a little more ceria would then increase the emissivity, and cause greater radiation and a fall in temperature, so that the light would decrease. A decrease of ceria would diminish the emissivity, so that though the mantle became hotter, it would radiate less of all wave lengths.

Though this simple explanation may be ample, it does not follow that there may not be all sorts of curious things—such as selective emission, luminescence, catalytic action, resonance, unstable oxidation, and other occurrences, whose names are as impressive as vague. They may be discussed in turn.

By selective radiation may be meant that a body at the temperature of a black body emits some rays and omits others, or that it has the power of emitting more refrangible rays than a black body at the same temperature. If two black bodies are in a reflecting envelope at the same temperature, each radiates to, and absorbs power from, the other. The heat in each is in a state of degradation corresponding to the temperature; and in a state of equilibrium it must be radiated and absorbed by each without further degradation. Heat radiated from a black body into a closed space in equilibrium is thus not degraded. If a body only emits the portion of the rays of high frequency, thougn it may radiate less power or energy per second, that energy would seem to be of a higher grade than that of the black body at the same temperature, so that it can be degraded into radiation of lower frequency. If that is so, this sort of selective radiation violates the second law. Emitting more refrangible rays than the black body is worse still. It does not follow from this that a body cannot emit rays of high frequency balanced by another batch at low frequency, so that their degradation corresponds with the temperature. This form of selective emissivity has not yet been invented by the advocates of this theory.

There does not seem at present to be any thermodynamic reason why a hot body should not radiate a selection of rays, provided the energy radiated is not less degraded than the heat in the body, or, to put it the other way, as long as the energy has no increased "motivity," to use Lord Kelvin's term. For the radiant energy leaving the surface to have a higher motivity than the energy in the body is a violation of the second law. There is an interesting question as to whether the radiant energy leaving a hot surface can start with less motivity. I am not considering increase of entropy of radiation spreading out after it has left the surface, but whether there can be a sudden discontinuous degradation at the surface. Growth of entropy in the case of heat conduction, irreversible expansion, and diffusion, is a volume increase; and it takes place when the motion of the particles is not the same in all directions or is not diffused. Thus in heat conduction, the particles move more quickly when going one way than when going the other, though the distance is the same each way. In diffusion, the motion of the particles of the fluids is, on the whole, directional. Here the speed is the same, but the distance different. Similarly with radiation in space. It seems open to question whether there can be a sudden or discontinuous change of motivity as the energy crosses the surface, changing from sensible heat to radiation. Stokes's law, that a fluorescent body cannot give out radiation on the whole of a higher refrangibility than the radiation that induced it, does not appear to have been proved, but seems to have been rather a sort of automatic statement, unconsciously based on knowledge, sounding as if it must be right.

It may be said that an ordinary spirit or bunsen flame does not give any light to speak of, though it is hot enough to incandesce a mantle, and it certainly radiates a great deal of heat; and though it is not a surface, if its radiation has less motivity than the hot gases, there must be discontinuous increase of entropy there. Perhaps. But, on the other hand, it may make up for its low frequency radiation by some very high; and the blueness of the flame is significant. Again, in a flame it may be the slower-moving particles that combine.

Another theorv, very much to the fore in connection with electric lamps, is that different surfaces have different radiating efficiencies. The experimental evidence on

this point is very conflicting, and the conclusions are often, I admit, unsoundly drawn. There is direct evidence, due to Féry, that the emissive light-efficiency—candles per watt—varies enormously. At 1400°, for example, taking the efficiency of a perfectly black body as 1, lanthana is 17, thoria 9, a thoria-ceria mantle 7, platinum 5, chromium oxide 4, carborundum 3, carbon 1.3. On the other hand, chromium oxide and ceria in the reducing flame radiated more total heat per second than a black body—an absurdity which the author himself was the first to criticise. There is apparently a clear instance of selective or preferential emission in the case of erbia. In the flame it shows bright bands in the green. I have not tried a Nernst rod on it.

The next theory is that the mantle gives more light than that due to a simple hot body, owing to luminescence. I cannot deal with this theory, because I have no clear idea what luminescence is. If by luminescence is meant the phenomena of a mantle, it is no explanation of the phenomena to call them luminescence.

Catalytic action is also a little vague. The idea often seems to be that, by some action or other, the ceria can convert energy of chemical action directly into light. It must be remembered that chemical energy is not work; it is partially degraded, and may be best regarded as heat, of which only a portion $(\theta - \theta^1)/\ \theta$ can be converted into work. No catalytic action can restore chemical energy to a higher grade. But many of the chemists who advance the catalytic action theory are not men who would make slips of that sort.

The catalytic argument may perhaps be put something like this: If a mixture of gas and air is above ignition temperature, and is enclosed in a case from which no heat can escape, the speed of the chemical action will depend on the temperature, the pressure, and the relative amount of air, fuel, and combined products. We will take the pressure as constant. The rate of combination then depends on the combustion already completed. Suppose now the combustion takes place in a flame. Let us consider a small volume of burning mixture ascending. It can now radiate heat, and the temperature corresponding to a given proportion of fuel burned is lowered. If the reaction constant could be artificially increased, the flame would be hotter and would radiate more heat. The rate of radiation of heat keeps the flame temperature from rising to such a value that the reaction constant is zero, or that the products dissociate as fast as the fuel burns. If ceria has the power, by catalytic action, of increasing the reaction constant, the ceria may be considerably hotter than the flame; and catalytic action may thus cause the mantle to give out rays corresponding to a higher temperature than the flame, though not to a higher temperature than that corresponding to the chemical action. There must always be some degradation of energy.

It is said that ceria acts in a special way by wobbling from one state of oxidation to another. It is quite clear that an oxide cannot create energy or heat or light by wobbling; moreover, it cannot be in equilibrium in both states. If it is in equilibrium in one state, it cannot move out into a higher state. Again, chemists who put forward the oxidation theory are not likely to put it in such a form as this. Thus a more tenable proposition is to be sought. If the rate of combination depends on the collisions of suitable particles at suitable speeds, and if the lower oxide of cerium can hang on loosely to oxygen particles so that it has a stock of them, any fuel particle, hitting the ceria at suitable speed, can combine with oxygen. The ceria would thus heat the mantle above the temperature of the flame, or at any rate to a higher temperature than it would otherwise reach.

The next theory is that of "resonance." Particles of gas are vibrating and changing their velocity fast enough to produce light, but somehow do not produce it. Particles of solid, however, get set into vibration synchronously with the gas particles, and thus radiate energy of the same grade as the heat of the flame. But ceria is supposed to be specially timed to vibrate with frequencies corresponding to visible radiation; so it radiates more light than other solids. This really amounts to ceria doing the work of Maxwell's demon, except that it is working on waves instead of particles. It can get outside the second law just the same. Maxwell's demon is apt to come into radiation in many disguises. He is rather fond of being a very thin plate which lets only one wave length through, and reflects all others perfectly. I have seen him mixed up in proof of Wien's law in this disguise.

The explanation that there is nothing anomalous about the mantle, and that it gives light because it is very hot, has a "Jordan" simplicity about it which makes it unpopular compared with the "Albana and Pharpar" of luminescence and catalytic action. All the same, very simple explanations are often wrong.

INCANDESCENT GAS LIGHTING

By Thomas J. Litle, Jr.

Read before the first Annual Meeting of The Natural Gas Association of America, June 12, 1906.

To trace in detail from the date of its inception, to the present time, the growth of incandescent gas lighting, would be practically impossible, unless the entire

time of the convention was given to that purpose. Dr. Bunsen, the inventor of our invaluable Bunsen burner, little imagined that his burner would revolutionize the lighting and heating systems of the world. It was Dr. Auer von Welsbach, of Vienna, one of the largest chemists the world has ever known, who, in 1880, while working in Dr. Bunsen's laboratory in Heidelberg, doing spectroscopic work in connection with the study of some of the rare earth, found by experiment that he could impregnate a cotton fabric with a solution of rare earth nitrates and after burning the cotton away a delicate ash would remain, thus enabling him to study the material by the aid of the spectroscope, after it had been brought to incandescence in the Bunsen flame.

Mantles.—Later he conceived the idea of forming a hood or mantle of rare earths and suspending it over the Bunsen flame, to produce artificial illumination. He was discouraged by Dr. Bunsen and generally ridiculed and discredited by the scientific world at large and the gas fraternity in particular, like many others of our early inventors. For seven long years he experimented with many oxides, starting with erbium, which gave a brilliant green light, and finally, in 1887, producing the lanthanum-zirconium mantle, which gave approximately 12 candles to the cubic foot of gas. This was encouraging, when we consider that the flat flame burner gave only from 3 to 4 candles per cubic foot. Companies were formed in all parts of the world to manufacture mantles under the Welsbach patents, but owing to the fragility of the mantles and their rapid deterioration, the venture seemed complete failure. The Vienna factory and laboratory were sold. The American factory at Gloucester, however, struggled on with the lanthanum-zirconium mantle, and made heroic efforts to make it a commercial success, but it was uphill work; apparently the system was dying.

At what appeared to be the psychological moment for the industry, Dr. Auer, who had been constantly experimenting in his Vienna laboratory, with a view to producing a commercial success, struck upon the thorium-cerium mantle, which is the modern Welsbach mantle. With the early lanthanum-zirconium mantle natural gas, with its high heating value and unlimited pressure, looked attractive, but there were many difficulties. We were compelled to ship mantles from the Gloucester factory to our natural gas distributing centers, there burning off the coating and mounting the mantles on burners and carefully installing on the fixture of the consumer. To-day we see the mantle a phenomenal commercial success, spreading to uses never dreamed of by the pioneers. For example, we now make an especially hard inverted mantle for railroad car lighting, burning Pintsch gas, and several hundred cars are so equipped. These mantles are so hard and strong that they will last for several months and no anti-vibration device is found necessary to prevent their breakage. We are also making very large lighthouse mantles and shipping them to all parts of the world.

Burners.—The incandescent mantle burner has occupied the attention of the inventor ever since the inception of the mantle. The early burners appear to us now ridiculous, with the trestle-like appearance and their faulty design and construction. It is imagined by many that all burners are alike. They are, only in the fact that they all burn gas, but from the standpoint of efficiency there is a very marked difference. I have recently tested such a burner which gave an efficiency of but 15 candles to the cubic foot of gas, while a good burner on the same gas and at the same time gave 22 candles to the cubic foot. On natural gas the conditions for best combustion are slightly different from those with manufactured gas. In the first place, the high calorific value as well as the higher working pressure make it especially desirable for incandescent lighting. For the highest efficiency on any gas we endeavor to crowd as much gas with the required proportionate amount of air as possible within the mantle, thus as the gas pressure is increased the ability of the gas jet or jets to entrain air is greater in consequence of the increased jet velocity of the gas. This condition is especially noticeable on the high pressure lighting systems. The highest lighting efficiency ever obtained, to my knowledge, was with the New Process gas lamp, a self-intensifying lamp using two mantles, having a heat motor above operated by the hot products of combustion and in turn operating a fan blower, forcing a large volume of air at so low a pressure as not to be distinguished on the water gauge, mixing and pre-heating the air and gas and delivering to a combustion chamber, where it is burned with a soft blast flame. This lamp has given almost 1,000 actual candle-power, consuming but 20 cu. ft. of manufactured gas, which means an efficiency of nearly 50 candles per cubic foot of gas. On natural gas the efficiency would be considerably higher. The gas pressure is immaterial, when using this lamp, as the gas simply flows into the burner, the air being pumped. The natural gas burner, using as it does a gas of high heating value, must in consequence entrain more air than if the same volume of artificial gas were used, and as to increase the gas pressure increases the jet velocity with its consequent ability to entrain more air, we find that we require the higher working pressure for natural gas, the most common practice being to carry about three times the pressure necessary for manufactured

gas. When needle valve Bunsens are used, a smaller orifice is required for natural than for artificial gas, but the Mason multiple hole check as used in the standard burner of the Welsbach Company works equally as well with either gas. This is especially desirable, as it is often necessary to change from one gas to the other.

It has been found that the construction of a burner gauze had much to do with the proper working of the burner. A small spreader or washer secured to the center of the gauze, while giving the best results on artificial gas, gives comparatively poor results on natural gas, for as more air is proportionately required for natural gas, tne resultant mixture passing through the tube is greater, and in this case the spreader in the center of the gauze simply impedes the flow through the top opening of the burner, consequently a plain gauze is used. In addition to this, an extra gauze is supplied with each burner, to be placed in the mixing chamber should the excessive pressure cause the burner to roar.

For general work I prefer a four-ounce pressure for natural gas, and while it is perfectly possible to obtain a very much greater cande-power by increasing the pressure, the burner is likely to roar, to obviate which the extra gauze mentioned above should be used to more thoroughly mix the gas and air. The same result may be obtained by lengthening the Bunsen tube. This, however, gives the burner an ungainly appearance. The lower pressure, therefore, is more desirable, as the use of a lower gauze causes considerable trouble to the consumer on account of its collecting dust, which the consumer invariably neglects to clean out when renewing the mantle.

It is of the greatest importance that the gas pressure should be held uniform, and while good burners will operate satisfactorily over quite a wide range, if carefully adjusted, at the mean pressure, they are more frequently over-adjusted at the lower pressure by the consumer, and as the pressure increases the flame will stream up through the mantle. The adjustable gas check has been of the greatest service to the incandescent lighting system, and is absolutely essential, even though the gas pressure in the building is held absolutely uniform, for every mantle has a variable form, one having a full shape requiring considerably more than a tapering mantle, and it is consequently found necessary to adjust the gas check each time a mantle is placed on the burner. The external cap support mantle is by far the best for use on natural gas. The center support necessarily requires a socket to secure it in the center of the gauze, which socket is retained in position by the use of a washer, and, as before mentioned, this washer greatly interferes with the working of the burner. Never was cleanliness nearer to godliness than in the incandescent gas burner. Any accumulation of dust on the inner surface of the Bunsen tube or under the gauze will greatly reduce the efficiency of the burner and quite frequently will cause the mantles to carbonize. It is highly important, therefore, that you educate your consumers to clean the burners each time they renew mantles and more frequently if you can get them to do it.

Gas Arcs.—The gas arc lamp has been successfully adapted to natural gas. I have gotten the best results by using a high alabaster globe, surmounted by a brass stack or draft inducer. The globe should be of large diameter and high, in order to remove it as far as possible from the mantle flames. In addition to this, the high globe, when used in conjunction with the metal stack, gives in effect a long chimney, which is especially desirable on natural gas. The metal stack should not be too small in diameter, as there will be a tendency to check the draft rather than to augment it, as we are handling a large volume of the heated products of combustion and air. The nickel finish also stands better on the stack of larger diameter. This stack should be made of heavy weight sheet brass, heavily nickel plated, as I consider the substitution of sheet iron for brass a great mistake in lamp manufacture, as such shells frequently leave the drawing dies badly wrinkled, and they will never take as good a nickel finish as the brass shell. They also show a tendency to rust. I have seen such lamps rust-pitted over their entire surface. The arc lamp gives the best results when the burners are equipped with plain gauzes, and the mantles should be suspended from above, and not on center supports, as there is a marked increase in candle-power when the wire gauze is used instead of the pierced metal cap carrying a center support. The old opal glass ceiling shield has been superseded by a metal baffle plate, and the glass reflecting shade has been omitted, leaving but one piece of glassware to maintain. I am now referring to the lamp using a large pear-shaped alabaster globe, scientifically designed to softly diffuse most of the light below the horizontal, making the reflecting shade seldom necessary.

Inverted Mantle Burners.—The inverted gas light has made its début on the American market, and, while there are a great many worthless burners and mantles being sold, the mere fact that they are sold would indicate a demand for a good burner. I may say that after a great deal of experimental work in all parts of the country we have succeeded in producing a burner and mantle which I believe will prove as successful as the standard upright burner, and one that will lend itself to the adaptation of a variety of glass-

ware. All will concede the greater decorative possibilities of the inverted light. The new burner works equally well on natural or artificial gas. The efficiency is extremely high, and the useful light, *i. e.*, the lower hemispherical candle-power, is much greater than with the upright burner. We have obtained with a flat opal shade and a clear cylinder, on artificial gas at two inches pressure, three cubic feet gas consumption, 118 candle-power directly under the lamp, while with the deep cone mirror gas reflector suitable for store window lighting, 277 candles were obtained on three cubic feet of gas. Much better results can be obtained on natural gas.

Tinted Light.—The most important factor in incandescent gas lighting is the selection of the proper mantle, and the best mantle is one giving a mellow light, heavily saturated with the lighting fluid. The mellow light mantle, in addition to the fact that the light is softer and more pleasing to the eye, is more efficient both initially and after burning for a long period. A 1,000-hour endurance test of the mellow mantle will frequently show at the end of the test a drop of only 25 per cent. or 30 per cent. in candle-power, while the white light mantle will have dropped 50 per cent. or even 60 per cent. during the same period. The mellow mantle is also stronger and shows a lesser tendency to shrink. All mantles whiten with age, due to the fact that the cerium becomes inactive, consequently the greater the cerium content of the mantle the longer can it be burned before giving that greenish ghastly glare which is so severely criticised by your friends, the electric light men.

Maintenance.—In electrical circles it is deemed expedient to discard lamps after they have dropped 20 per cent. from the initial candle-power, which means with a 3.1 watt lamp an average life of about 600 hours, consequently I believe a similar practice would be beneficial to the gas business. Mantles could be renewed after they had dropped off 25 per cent. or 30 per cent., and if the mellow light mantles were used this would not be an unreasonable proposition; with a low grade white mantle, however, which is very lightly saturated with the lighting fluid, you would be compelled to replace them every couple of hundred hours to maintain your high standard of lighting, and, of course, this would be prohibitive. Little wonder, then, that we see such miserable demonstrations of incandescent gas lighting throughout the country, where the cheap white mantles sold by peddlers are used. Quite frequently the peddler or unscrupulous dealer will purchase mantles for six or seven cents and sell them for as much as twenty-five cents, and the poor public blame their lighting troubles on the gas man.

The question is frequently asked why high grade mantles sometimes break as readily as the cheaper mantles. This is caused by shock in transportation or rough handling on the part of the dealer or consumer. To obtain the best results in incandescent lighting, therefore, I would suggest that you carefully educate your customers to the use of the mellow light mantle, to handle it carefully and keep their burners clean. This is being successfully done at several points throughout the country.

WIRING AND LIGHTING EQUIPMENT OF AN EIGHT-ROOM $3,500 RESIDENCE

By J. R. Cravath.

Read before the Ohio Electric Light Association, Aug. 21, 1906.

The proper wiring and lighting equipment of an eight-room residence of a cost of about $3,500 is the problem which has to be dealt with more frequently by most of the members of this association than any other class of customers' installations. The choice of the subject by your committee is therefore especially commendable. My first idea when I started to prepare this paper was to simply draw up a single set of specifications for an eight-room house. After considering the matter further, however, I have concluded that the value of this paper to the members would be much greater if I were to outline a number of good schemes for each room, thus giving opportunity for a choice among several efficient schemes for each room. This is what one would naturally wish to do in dealing with prospective customers, and consequently it is the course I have pursued here.

To begin with, we will assume that our eight-room $3,500 residence has, in addition to the basement, the following rooms:

Living room,
Library reception-room, or den,
Dining-room,
Kitchen,
Pantry,
Four bed-rooms,
One bath-room.

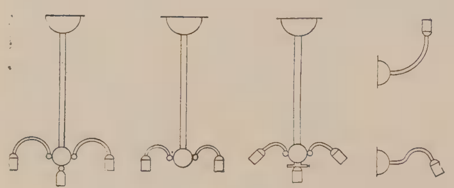
As far as these rooms are concerned, we have before us a fairly definite and uniform problem in nearly all the houses which we come across. The principal variations will be in the hall and stairway arrangements and porch. We will take up the rooms first, giving for each room the choice of several different schemes which

are designated A, B, C, etc. The five drawings are given simply to indicate the number and position of sockets. The fixtures may be as plain or as elaborate as desired.

LIVING ROOM.

Plan A—Place one 3-light chandelier of the general style indicated in Fig. 1 in the center of the room. Equip the center socket with a prismatic reflector which will throw a strong light down under the chandelier for reading purposes. Equip the chandelier arms with Holophane Class B stalactite globes for the general lighting of the room. These diffuse the light and direct it downward. The prismatic reflector on the center socket should be chosen with reference to the amount of area to be illuminated. If not more than two persons are likely to wish to read under the chandelier, a very deep concentrating reflector can be used. If several persons are likely to be reading in the room in the evening, one giving a wider distribution is necessary. The general lights on the chandelier arms should be sufficient to light the room well in all parts on special occasions. If the room is large, use a 3-arm chandelier, but this is seldom necessary in a house of this size.

Plan B—Use a fixture like that shown in Fig. 1 and equip the center socket with a 7-inch opal dome reflector and frosted



FIGS. 1 2 3 4 & 5

lamp. Equip the chandelier arms with frosted lamps in small opal ball reflectors. This will give similar results to Plan A with a slightly lower cost of glassware. Some will prefer the opal to the prismatic glass. Opal reflectors cannot be obtained, however, which concentrate as much light over a small area as do prismatic reflectors.

Plan C—Use such a chandelier as in Fig. 1 and equip the chandelier arms with Holophane Class B stalactites and the center reading socket with a Holophane Class A stalactite. This will not give as good a reading light as Plans A and B, but it is more artistic in appearance and places all lights behind diffusing globes.

Plan D—Use chandelier indicated in Fig. 1 and equip the arms with sand blasted or frosted balls. On the center socket for reading purposes use a prismatic reflecting ball with lower half frosted. This is less efficient than any of the previous arrangements proposed, but very handsome.

Plan E—Place a hemisphere in the center of the ceiling, using inside the hemisphere one lamp pointed straight down and equipped with a flat reflector. Either a ground glass or Holophane hemisphere can be used with good efficiency. An opal or opaline hemisphere should not be considered. Place a bracket like Fig. 5, with lamp at an angle of 25 degrees, at the point in the room which the owner wishes to use for reading. Equip the bracket with a frosted bulb lamp and a prismatic reflector.

It is also a good plan to place in the corner of the room which is likely to be used for a piano a flush wall receptacle. This wall receptacle can be used for a piano lamp, fan or ornamental table lamp. The electric table lamp is not to be recommended for useful reading purposes, however. Better results can be secured by putting the reading lamp in a good reflector on the chandelier or wall bracket, as indicated in the previous plans outlined. Of course with the reading light on the chandelier the table should not be placed under the chandelier as that is the very place which should be occupied by the persons reading in order to get the best light.

LIBRARY.

In the ordinary eight-room house there is usually a small room which is used variously, according to the ideas of the owner, for a library, reception room or den.

Plan A—Place in the center of the room a 2-light chandelier of the general design indicated in Fig. 2. Equip with two prismatic reflectors. These will light the library table, which will naturally be placed under the chandelier, and will also give enough light on the book shelves to read book titles. A portable table lamp is good on a library table when the reading is done on the table close to the lamp.

Plan B—Use chandelier, Fig. 2, and equip with 7-inch opal dome reflectors. This will give about the same results as Plan A. Use frosted lamps in either case. One wall receptacle is also advisable in this room, as there is likely to be a desk in one corner calling for a portable desk lamp or a fan, or both.

DINING ROOM.

Plan A—Place a 1-light chain pendant in the center. Equip with an art glass dome and have the lamp inside point straight down. Over the lamp inside put a prismatic reflector of a type which will give an even distribution of light over the entire top of an ordinary dining table. Avoid the use of a reflector which concentrates light in the center of the table at the expense of the edges, as the effect will not be good. A ground glass bottom on the dome is desirable.

Plan B—Use Plan A, but equip the lamp inside the art glass dome with a fluted opal cone reflector.

Plan C—Use a chain pendant, and equip with a decorated 11-inch opal dome reflector. This, of course, will cost considerably less than the art glass dome.

Plan D—Use style of chandelier indicated in Fig. 3. Equip the center socket with an 8-inch opal dome which will distribute light well over the table for all ordinary occasions. For lighting up the room more thoroughly, equip the chandelier arms with bare, frosted lamps. The lamps on the arms are seldom needed.

KITCHEN.

Plan A—Place a pendant or bracket with lamp socket pointed straight down, 7 feet above the floor, a little to one side of the sink, and equip with a fluted opal cone reflector. In some other part of the room, where it will cover range and table, place a pendant with a lamp above 7 feet from the floor. Control both lamps with one switch, and use chain pull sockets for turning off one lamp when not needed.

Plan B—Place one lamp in the center of the ceiling. Control by a switch and equip with a reflector which will give the maximum intensity obtainable in the direction of sink and range. In the ordinary 10-foot square kitchen, this reflector in the present state of the arc will be a prismatic reflector, which gives an intensity of over 30-candle-power at the desired angle. The fluted opal cone and the opal dome reflectors are also good ones to use in such a location.

PANTRY.

Plan A—Place one bare lamp on a drop cord 6½ feet above the floor.

Plan B—Place the lamp at the ceiling, control it by switch and equip it with a fluted opal cone reflector.

BED ROOMS.

In bed rooms, the owners are likely to balk at the cost of providing enough outlets to give the most perfect bed room lighting. In outlining the following different schemes for bed room lighting the author began with the simplest and cheapest and from that went step by step to more expensive and more satisfactory plans. Although some of the plans proposed may seem crude, all realize the desirability in many cases of keeping down the cost of installation. The owner, if left to himself, and the wiring contractor, will frequently provide well for the rest of the house, but put the bed rooms off with a single bare lamp on a few feet of flexible cord.

Plan A—Where one outlet only is allowed, place a 3-lamp wireless cluster on the ceiling in the middle of the room. This will give an outlet to which various portable devices can be attached and the curling iron heater, heating pad, etc., will be taken care of. For the lighting of the room as a starter, use a portable wall bracket which can be hung on a hook anywhere in the room, and attach it by means of flexible cord and an extension plug to the wireless cluster on the ceiling. The portable wall bracket used should in general form resemble the ordinary permanent bracket with the lamp mounted at an angle of about 25 degrees from vertical. Equip the portable bracket with a fluted opal cone reflector or a prismatic reflector giving a fairly wide distribution. The portable wall bracket will probably most of the time be hung over the center of the dresser mirror. It can also, at a moment's notice, be placed anywhere else in the room or hung low for reading purposes. If provided with chain pull socket, it can be hung over the bed within reach of a person in bed, for use in the night. The portable bracket is somewhat of a makeshift, but it comes nearer to giving light in all places that light is likely to be wanted in a bed room than any arrangement not providing three or four outlets.

Plan B—Same as Plan A, but add a drop cord in the middle of the room and equip the lamp with an opal or prismatic reflector. Also mount bare, frosted lamps each side of the dresser mirror and attach these by flexible cord and extension plug to the receptacle at the center of the ceiling. This plan will give as completely lighted a bedroom as one could wish, but, of course, has the objection of considerable exposed flexible cord. This, however, is not as serious as might be thought.

Plan C—Place a 1-lamp pendant in the center of the room with a prismatic reflector and a 1-lamp bracket of the style indicated in Fig. 5 over the center of the dresser mirror. This will call for two permanent fixtures, the lamps on both of which will, as a rule, be used at the same time. It will, therefore, be advisable to provide some of the well-known means for getting current for heating devices from one or both of these outlets without disturbing the lamps and reflectors on the fixtures. This can be done by providing a flush wall receptacle close beside the fixture outlet, or by using a type of canopy receptacle or tap recently put on the market. One lamp over the center of the mirror is sufficient for most purposes except shaving, consequently where this Plan C is used a portable shaving mirror with lamps on each side must be hung up somewhere in the room and attached by extension plug and cord to one of the outlets when needed.

Plan D—Place a bracket each side of the dresser of the general style shown in

Fig. 4. Use frosted upright lamps. Place a 1-lamp pendant with lamp 6½ ft. above the floor in the center of the room for general lighting and reading. The lamp bulbs each side of the dresser should be 5 feet 9 inches above the floor. This will be a little high to provide the best shaving light, so that if shaving is to be done a portable shaving mirror with a lamp on each side can be hung at some convenient point in the room and attached to one of the dresser bracket sockets.

Plan E—This plan represents the most perfectly lighted bed room, but calls for more outlets in each bed room than the average owner of a $3,500-residence is willing to pay for. Place a short 2-lamp chandelier of the general style shown in Fig. 2 in the center of the room with lamps 7½ feet above the floor controlled by a switch. Equip the lamps with 7-inch opal dome reflectors, or prismatic reflectors giving an approximately similar distribution. Place a bracket of the style indicated in Fig. 4 each side of the dresser with the lamp bulb 4 feet 8 inches above the floor, using frosted bulb lamps with no shades. Place a bracket of the style indicated in Fig. 5 over the center of the dresser mirror, and equip with fluted opal cone reflector or prismatic reflector, giving similar distribution. Place over the head of the bed a bracket of the style indicated in Fig. 5. Equip with chain pull socket and a concentrating type of prismatic reflector.

HALLWAY AND STAIRS.

Arrangements of halls and stairs differ so much that general rules are hard to formulate. It is usually advisable to have one lamp half way up the stairs, where it will light both up and down the stairs, and control this by a 3-way switch at the top and bottom of the stairs. The glassware used on the stair lamp must depend altogether on the direction in which the light is wanted. If it is placed very high on the ceiling of the second floor (as it must be in some cases), a concentrating prismatic reflector should be used. If it is placed on the stair landing to light both up and down, a sand-blasted ball is best.

BATH ROOM.

Plan A—Place one lamp at the ceiling with fluted opal cone reflector and control by a switch.

Plan B—Place one lamp on a pendant 6½ feet above the floor with chain pull socket and a prismatic reflector giving very wide distribution.

BASEMENT.

Plan A—Place two or three lamps with flat porcelain reflectors at points where they are likely to be needed. Control all lamps with one switch and use turn-down lamps.

PORCH.

Plan A—Place one lamp in a 7-inch opal dome reflector over the front door. Control by a switch inside the house. In some cases the owner will wish to have this lamp controlled also from the outside, in which case 3-way switches can be used. Whatever is done, the lamp should be controlable from the inside for obvious reasons of safety and convenience.

HEATING CIRCUIT.

No new home should be wired these days without a special heating circuit of No. 8 or 10 wire ending in plug receptacles of ample capacity in the kitchen, and in one similar plug receptacle in the dining room. The dining room receptacle can usually best be placed in the baseboard near the sideboard, although some prefer to place it under the dining room table. Receptacles designed especially for the heavy current used by some heating devices should be used. The majority of receptacles used for other purposes are too light. The small heating devices used elsewhere than in the kitchen and dining room can be attached to ordinary lamp sockets.

GENERAL NOTES.

The living room and library chandeliers, although controlled by wall switches, should be equipped with chain pull sockets so that some of the lights can be turned off at the chandelier without an unreasonable reach by a short person. This obviates the expense of a double circuit to a chandelier. In the dining room, if desired, the expense of a wall switch can frequently be done away with if a chain pull socket is used on the dining room fixture, since it is usually easy to locate the dining room fixture in the dark by virtue of the fact that it is over the middle of the table.

Prismatic reflectors are made to give such greatly different forms of light distribution that they should always be selected either by their photometric curves, which are frequently obtainable from the manufacturers, or by actual trial.

DRAWING UP SPECIFICATIONS.

After we have decided upon the exact location and equipment of fixtures, it is important to have some system whereby specifications for the work can be drawn up rapidly and systematically, so that the necessary information and instructions can be put in the hands of workmen, contractors, and bidders. Even where a central station company does the wiring itself, the man who plans the job must have some way of putting down his ideas so that others can

follow them easily. The first thing to be done is to take a set of floor plans of the house and mark upon these plans the location of the various outlets, indicating the number of sockets to be provided at each outlet. In order to avoid the great amount of work which would be necessary to draw up complete typewritten or manuscript specifications for each room, a table or blank schedule of the form shown in Fig. 6 will be found of great value. This table provides for most of the common items in connection with any ordinary job, and the extraordinary things can be taken care of under remarks' column. It is a quicker and easier job for the contractor and workmen to get information off such a schedule than from any other form of specification, and at the same time the schedule can be made out very rapidly. In the column specifying the kind of fixture to be used, reference can be made to a rough sketch indicating the general arrangement of sockets on the fixture; or if selection of the fixture is made at the time the schedule is drawn up, the maker's catalogue number of the fixture can be used instead of a sketch number. The accompanying schedule is filled out for a part of the wiring and lighting of the proposed house, using the plans marked A in the foregoing portions of the paper. It will not always be necessary to fill out all of the items on this schedule, nor is it necessary that all of the schedule be filled out at once. The portion necessary for the wiring can be filled out when the wiring bids are to be received, leaving other portions until later.

In planning the location of fixtures, and especially that of wall brackets in bed rooms, it is desirable to have some means of showing quickly the probable location of furniture, and of trying the furniture in different locations. In going over the lighting plans with the owner, an excellent plan is followed by the Cleveland Electric Illuminating Company. Blocks of the sizes of various pieces of furniture have been made up to the same scale as the architect's plans so that they can be set on the plans and the owner of the house can decide intelliegntly where to locate the furniture.

Against possible changes in location of furniture there is no safeguard, except the possible inconvenience of such changes and the use of lamps mounted directly on the dresser. Where such work is being done it is a good plan to have blank schedules printed on tough, thin bond paper from which blue prints can be obtained after the original blank is filled out. Where not enough work is done to justify this expense, a blank schedule drawn up on tracing cloth can be used to make blue prints and the blue prints can be filled out in black ink or red pencil.

ROOM OR LOCATION	No. of Outlets	No. of Fixtures	No. of Lights Per Outlet		Height of Outlet	Height of Socket	Style of Socket	Kind of Switch	Style of Fixture		Catalogue No. of Glassware	Diameter Holders	Lamps		REMARKS
			Gas	Electric					Sketch No.	Catalogue No.			Number	C.P.	
First Floor															
Living room	1	1		3	Ceiling	6'10"	Pull	Push	1		1-#2641 2-#3150	1 5/8" 3 1/4"	1 2	16 8	
" "	1	-	-	-	Base board	—	—	—	-	-	—	—	-	-	Baseboard receptacle
Dining "	1	1	-	1	Ceiling	6' 0"	Pull	Push	-	‡245	#7381	2 1/4"	1	16	
Library	1	1	-	2	Ceiling	6'10"	Pull	Push	2		#2621	1 5/8"	2	8	
"	1	-	-	-	Base board	—	—	—	-	-	—	—	-	-	Baseboard receptacle
Kitchen	2	2	-	1	Ceiling	7' 0"	Pull	Snap	-	‡090	*4184	2 1/4"	2	8	
Pantry	1	1	-	1	"	6'10"	"	—	+	0	—	—	1	4	+ Drop cord

Note: #Catalogue of X Glass Co. *Catalogue of Y Glass Co +Catalogue of Z Fixture Co

Review of the Technical Press

AMERICAN ITEMS

INCANDESCENT LAMP RENEWALS. By J. W. COWLES.—*The Electrical Age*, September, 1906.

A discussion of the problems confronting central stations that furnish free renewals of lamps. The writer concludes that the practice of depending upon the customer to send his old lamps in for renewal is unsatisfactory, and suggests that Stations make out a regular schedule for their different customers of the times when they will call for exchanging lamps, so that the old lamps may be ready for delivery.

DISCRIMINATION IN MUNICIPAL LIGHTING. By J. S. Codman.—*The Central Station*, September 1, 1906.

A brief exposition of the discrimination arising from the method of charging a uniform rate per kilowatt hour. As the writer states: "To sum up, it may be stated that a uniform price per kilowatt hour not only means a variable rate of profit on customers, which is improper, but also means a higher price per kilowatt hour to the customers as a whole."

"It may be objected that it is impossible to make a schedule of prices proportional to the cost of supply and that therefore a uniform price per kilowatt-hour is the best. It is probably true that a scale of prices exactly proportional to costs is practically impossible to obtain, but nevertheless it can be approached very closely. Various systems of charging with this end in view are already used by many private companies, which fully realize that reduction in the average cost makes possible a reduction in the average price and a consequent increase of business."

After discussing some of the different systems of charging, the writer refers to his paper presented to the Association of Electric Lighting Engineers of New England, under the title, "Discrimination in Rates."

ILLUMINATION AT THE EAGLE'S CONVENTION, MILWAUKEE.—*Electrical World*, September 1, 1906.

A description of the method of temporarily installing incandescent lamps for decorative lighting.

"The general plan was to place an arch of lights across the street above each railway span wire. This arch of lights was suspended from a span wire above the regular trolley span wire. The arch consisted simply of the two supply wires from which the lamps were fed. These supply wires were supported by porcelain insulation of the type which take two conductors side by side. These insulators were held together by an eye-bolt to which the wire was attached by which it was hung from the span wire. The lamp sockets were of the type commonly used in such decorative lighting and were supported by the two conducting wires. Lamps were placed about one foot apart. On the central part of the arch clear bulb lamps were used, and on the ends red and green bulbs. In some cases the steel poles were not high enough on one side of the street to take the extra span wire, and in these cases a neat wooden extension was driven in the top of the steel pole. Although the plan is best suited to temporary lighting it is substantial enough so that it could be made to serve well as a permanent down town lighting scheme in small villages where some special lighting is wanted and steel arches are prohibitive in cost."

THE TUNGSTEN LAMP.—*Electrical World*, September 1, 1906.

A review of the various methods that have been worked out for the manufacture of incandescent lamp filaments from tungsten and its alloys.

GAS LOGIC.

This is the title of a monthly periodical used for the purpose of promoting the use of gas in New York City. While it is therefore, strictly speaking, a commercial publication, it is worthy of recognition among the technical journals on account of the extremely attractive form in which it is gotten up, as well as the practical value of its contents. The articles of a technical nature in the September issue are "How the Mantle is Made," by Victor A. Rettich; "Under Gas-light in London," by Harold A. Stewart, and "The Living Room," which deals with the furnishing and lighting of this most important room in the home, concerning which it says:

"The placing of the lights is even more important. A good general rule is to have them high enough to shine in nobody's eyes, and to assure the ligt coming wholly from above—unless, of course, there is a shaded table lamp. Nobody, off the stage and without "make-up," looks well in a light that strikes upward from some point below the face. Light is a painter of pictures, and sometimes, like a freakish painter, it caricatures the sitter."

FOREIGN ITEMS

THE NEW FORMS OF INCANDESCENT ELECTRIC LAMPS

By Dr. C. R. Boehm.

Journal für Gasbeleuchtung und Wasserversorgung (Munich), August 18.

Improvements in electric incandescent illumination have been made by using other substances than carbon for the production of the luminous body, and by improving the existing forms of carbon filament. High efficiency lamps can be conveniently prepared only for high light units, and the low efficiency lamps are not economical. The powdering of the carbon, one effect of which is an increased current consumption, grows as the temperature rises. Therefore, the carbon-thread is not equal to the requirements of a rational illumination, which demands the highest white temperatures possible for an economic light source, because this principle states that a flux of light increases by the 5th power with the doubling of the temperatures. For instance, an electric incandescent lamp, the carbon thread of which gives an absolute illumination of 30 c.p. at a temperature of 2,000 degrees, does not give twice that amount at 4,000 degrees, but 2 x 2 x 2 x 2 x 2 = 32 times as much, or about 1,000 c.p.

We have already fully described in our previous issues the Nernst lamp, the osmium lamp, the mercury lamp, the Hewitt lamp, the tantalum lamp, the Wolfram lamp, etc., and we shall now give the others that are much in use.

THE UVIOL LAMP.

Besides the broad and visible radiation there is also in all kinds of light a dark radiation that is invisible. It is called, if of a greater wave length than the visible light, ultra-red, or heat radiation, and if of a shorter wave length, chemical, actinic, or ultra-violet radiation. The discovery of the latter rays has been made possible by new and perfected apparatus, and their importance in physics, as well as in medicine, is now well established; but in order to develop these radiations for more general purposes, it is necessary to make the apparatus and its use more accessible, as in the Hewitt lamp.

Since ordinary glass does not let the ultra-violet rays pass, but absorbs them, it was necessary to seek another medium, and molten rock-crystal was first experimented with. Mercury lamps were thus made from quartz-glass by W. C. Heraeus, in Hanau, which caused a sensation among scientists in 1905. The strong smell of ozone surrounding it indicated the wide extension of ultra-violet rays produced by them, which reacted on the oxygen in the air.

The spectroscopic investigation showed that the extension of the wave of this lamp reached as high as 220 μ. The question was solved, but the high price of rock-crystal and its manufacture obstructed its general use for mercury lamps, especially for medical purposes.

Dr. Zschimmer, of Jena, has lately produced a peculiar glass compound that allows abundant ultra-violet light to pass, so that he could make improvements on the mercury lamp that are liable to satisfy all expectations, scientifically as well as practically.

Since the spectrum reaches 253 μ in the new glass compound, which the doctor called Uviol (ultra-violet), it is fully sufficient, especially for medical purposes, because there is no need for the short wave rays on account of their low power of penetration (Axmann). The visible part of the spectrum reaches only to 579-405 μ, then comes a long scale of chemically active rays, 2/3 of the length of the spectrum. The special mercury lamps of Heraeus and Schott are therefore highly advantageous arrangements to transform electric energy into useful light energy of small wave length.

It is expected that photography will profit by this source of light on account of the innumerable short waves. Schott's Uviol lamps and the Heraeus rock-crystal lamps are well suited for taking and copying pictures in northerly climates with their short and dark winter days.

In chemistry also it is likely to be used for causing two substances to combine, similar to the known action of sunlight on chlorine and hydrogen to form hydrochloric acid. Also, colors may be tested as to their genuineness. The bleaching action of sunlight is a slow chemical process caused by the ultra-violet rays. In Germany the dye works have to send south to test colors on account of the unfavorable climatic conditions, and because there is no artificial light—not even the electric arc lamp, that gives the same effect as the sun. Many tests have been made with the Uviol lamp, and they have given good results, so that in future the color question will require less time.

These rays of the Uviol lamp have a peculiar effect on the smaller insects, as it kills them—not by the heat, as was shown when an ordinary fly was killed within a minute, when brought within 1½ cm. of the lamp; thousands of small dead insects could be found under a lamp that was hung in an open window on a summer

night. Also microbes were killed under its influence just as with sunlight.

But the most important and most interesting application of the ultra-violet light is in the treatment of skin diseases. Since Finsen's sensational treatment of lupus, violet light is acknowledged as one of the most powerful cures. It cures this awful disease that heretofore could only be cured by surgical operations, in a natural way by exciting the proper physiological processes in the diseased tissues. But the high price of an apparatus that produces this light, and the difficulty in handling it, hinder its general application; this is true especially in the concentrated carbon light of Finsen. Since his results were published attempts were everywhere made to substitute the Finsen apparatus with a smaller and cheaper one, but until lately without success. The iron light, rather in short wave rays than the carbon arc light, is only superior in superficial effect, but far inferior where a thorough effect, that depends on the abundance of the blue, violet, and ultra-violet rays, is required (Kromayer).

Progress in the treatment with light depends on a simple, cheap and convenient light-source, the effect of which is not only equal to the Finsen light, but even superior to it: the special mercury lamps of Heraeus and Schott are light-sources of this kind. The advantages of these lamps are: 1, Shorter duration of treatment; 2, treatment of larger areas; 3, treatment of mucous membranes; 4, no hurrying; and 5, cheapness on account of small current consumption, etc.

FLUORESCENCE LAMPS.

The lamp constructed by Dr. Schott, called the Fluorescence Lamp, and lately exhibited at the convention of scientists in Meran, is simply a kind of Uviol lamp, modified in such a way as to suppress and avoid a great part of the long wave rays; for that reason it gives no bright illumination, while the outside and arrangements are the same.

All objects in the light of these lamps appear indistinct and blurred; though it is dark it causes on all kinds of substances surrounding it a general fluorescence; as, for instance, on rhodamin, fluorescin, and uranium glass, causing these substances to shine brighter than the lamp itself. Vaseline, lanoline, soaps, and the human skin show a peculiar play of colors. Since in the latter case in daylight changes of the skin are made visible, we possess in this lamp not only a highly valuable means for therapeutical and pathological purposes, but also for diagnosis.

This fluorescence of the lamp, which naturally has an extraordinary value in physics, will undoubtedly be used also for treatment by the so-called sensitizing of light by means of fluorescent solutions, which are now used to a considerable extent in medicine. All these actions are explained by the chemical action of the ultra-violet rays.

The late Mr. Hertz, of Bonn, discovered that ultra-violet light is capable of setting negative electrodes free, and it may be assumed, therefore, that mercury lamps also cause ionization; an electroscope brought near it showed this effect clearly, which reminds us, just as the described fluorescence, of the qualities of radium.

In working with ultra-violet rays it is necessary to protect the eyes by means of eyeglasses in order to prevent a violent inflammation. More than fifty years ago it was the opinion of the French scholars Regnault and Foucault that the violet and ultra-violet rays are injurious to the eye, because they excite its fluid to fluorescence, tire the nerves, and change the transparent texture.

Since, then, the mercury light reacts strongly upon the visual purple of the eye, as the medium of vision has been called by Koenigs, the eye is sooner exhausted by this kind of illumination than by the ordinary sources of light. Hence those kinds of illumination are preferable in hygienic respects that give a yellowish or reddish light, though with regard to intensity the opposite is true.

ORTHOCHROM LAMP.

Since the peculiar disagreeable color of the light of the Hewitt lamp was the greatest obstacle to its general use, efforts have been made to remedy this defect. This objection has been met in the so-called Orthochrom Lamp by putting ordinary electric incandescent lamps in the circuit, or by changing the mercury waves into red waves by the fluorescence of rhodamin. The latter process means a loss of light of 25 per cent., but so far, they have been used, on account of their extraordinary actinic powers, for photographic purposes only. The most valuable property of the Hewitt lamp is the possibility, as Hewitt pointed out, of transforming alternating currents into continuous currents.

Many experiments have been made to substitute other metals for mercury, but never with success. The volatilization and condensation of the negative electrodes is too difficult in the case of other metals; nor have any good results been obtained by the use of other gases with mercury electrodes.

ZIRCONIUM LAMP.

Moissan has lately proved that the metallic oxides, that were thought to be unchangeable, may be decomposed by high temperatures. Reactions that were incomplete at the temperatures of the ordinary furnace were much more complete at the temperatures of the electric furnace. Many compounds are broken up at these high temperatures, and others until recently un-

known, are produced in a well established and stable form; as carbides, boricides, and silicides.

Attempts to reduce all metallic oxides by means of carbon in the electric arc lamp resulted in well-defined compounds of carbon with the metal, forming carbides. The metallic carbides may be divided in two classes: the one is soluble in water, the other very stable. To the latter class belongs zirconium carbide, which is now used in the manufacture of incandescent lamp filaments.

According to the patents taken out by Sander, the business management of which for Germany is in the hands of the Zircon Incandescent Lamp Works of Dr. Hollefreund & Co., in Berlin (for the foreign patents a zirconium company has been formed in Brussels), zirconium incandescent mantles are made from the hydrogen or nitrogen compounds of the rare earths, especially of zirconium, with the aid of an organic binding means. To obtain these compounds the zirconium earths are reduced by magnesium, according to Winkler, in a current of hydrogen or nitrogen gas (in practice the hydrogen current alone is used). In contradiction to the analytical results of Winkler and Bayle, we should obtain the pure hydrogen compounds, if we work, according to the patents, with a surplus of magnesium metal and the addition of heat from an outside source. According to Hollefreund the figures of the analysis give the formula ZrH_4. To remove the magnesia and the residual magnesium the reduction product is dissolved in a weak solution of hydrochloric acid, dried, and then worked to a paste by means of a binding menstruum. It is best then to heat the thread obtained by pressing to about 300 degrees in an atmosphere of hydrogen after it has been dried, in order to avoid oxidation. The threads possess a very low conductivity, so that they have to be submitted to high currents in a subsequent treatment afterwards in the recipient or they have to be heated. In the latter case the ordinary voltage makes the thread glow, and it will always be a conductor because carbide formation has taken place. Then by means of a hydrogen current and gradual increase of voltage the thread is caused to shrink. As the voltage increases the thread changes its structure, becomes hard and metallic in appearance, and its electric qualities resemble those of a metal. According to Weddings such incandescent lamps burn at 2 watts per candle, and are suitable only for low voltages.

The zirconium carbon lamp was brought upon the market by the same company; it consisted of ordinary carbon thread having on the surface a thin layer of zirconium metal in place of the graphite coating. Lately an improved zirconium lamp is sold by Hollefreund & Co. that is supposed to burn with 1 watt per candle. The name implies that it is a lamp analogous to the osmium and tantalum lamp. According to the description of the recent patents it is a carbide lamp in which the percentage of carbon is decreased by suitable additions and processes. The carbides of all metals, including that of zirconium, have long been used for electric incandescent lamps. But only by adding other metals of high melting points, as, for instance, Wolfram and ruthenium, zirconium filaments could be made, the melting point of which lies higher than that of the zirconium carbide filament. Such lamps burned, according to Bojes, with 0.6 watt over 120 hours, and at one watt per candle, for 1,000 hours, showing in the first 500 hours almost constant values. The length of the thread is, for a thickness of 0.6 mm., about 5 mm. for 1 volt. The later zirconium lamps are especially suitable for low voltages, but, by connecting several incandescent filaments in series in one lamp, we may obtain incandescent lamps for voltages as high as 110 and 220. The new zirconium-carbide lamp is therefore arranged with three filaments for 110 volts.

IRIDIUM LAMP.

Along with the improved zirconium lamp an iridium lamp made its appearance lately. Iridium, like osmium, belong to the platinum group, and was mentioned as early as 1878 by Edison as applicable to electric incandescent lamps. Iridium is extraordinarily hard and brittle, and non-malleable. It can be rolled to a thickness of about 0.8 mm. Gulcher applied it in the manufacture of incandescent lamp filaments, and as nothing is known about it, it may be interesting to give here the description of the patent.

"A process of making thin and uniformly dense incandescent lamp filaments from pure iridium, in such a way that threads are made of iridium in a very finely divided condition, from which the binding means is completely removed by heating in the air, and dried in the air in a moderately high temperature, are then strongly heated in the open air until they shrink completely together."

Again: "Process for the production of thin and uniformly dense incandescent lamp filaments made from pure iridium according to the above, in which iridium ore is thoroughly mixed with the combining means, the thread formed from the stiff and plastic mass passed through a current of hydrogen, after drying, in order to reduce the oxide still contained in the iridium ore to metallic iridium, and then to heating the thread, consisting only of metallic iridium and the binding mass, to the highest white heat in the open air."

The iridium lamp is, like the osmium lamp, meant only for low voltages, and not to be regarded as a serious rival of

the carbon incandescent lamp, because iridium as well as osmium occur rarely in nature.

GRAPHITE FILAMENT LAMP.

Finally, it may be mentioned that the General Electric Company has obtained, by a special treatment of the prepared carbon thread, a so-called "metalized" carbon filament. This process causes such a decrease of resistance of the carbon, even changing the negative coefficient of temperature to a positive one, that thread of a metallic character may be obtained from it. In chemical respects they look like graphite, hence the name; so far only 2½ watts per candle have been reached.

Electric incandescent illumination is as yet only in its developing stage, one invention taking the place of another, as we have just seen. J. Lux, of Vienna, has a patent for the production of thin threads for electric incandescent lamps made of metal of a high melting point.

Comparative Economy of the Different Sources of Illumination.

The great improvements in the production of illumination during the last 30 years consist not only in an increase of light intensity, but also in a decrease of cost in the illuminating material or energy consumed.

The public, however, is being misled, and is taking too much for granted as to the quality of the different kinds of illumination in considering the low price of the amount of light produced. In comparing the different sources of illuminations the layman is furnished with tables that have been prepared under all sorts of conditions by well-known men, in which the efficiency of the different sources sometimes refers to spherical and sometimes to hemispherical candle power; nor is it mentioned whether the tests have been made with or without the use of globes and reflectors of different constructions.

A comparison of costs of the different sources of illuminations is only possible under certain restrictions, since the conditions and the requirements of the light sources to be compared differ greatly. For instance, it is not possible to compare offhand the source of light for a small working place in a closed room with another one that serves to illuminate a large hall; furthermore, the color of the light in many cases is the determining factor. Besides, it must be noted that the theoretical efficiency does not indicate the price of the running expenses of a single source of light. Electricity is a form of energy that, as the commercial situation is to-day, is much more expensive than the same amount of energy contained in petroleum or in illuminating gas; in a certain sense it is a luxurious form of energy. However, this is a purely outside matter that is liable to change, and in fact is changing, from day to day.

After the petroleum incandescent light, the incandescent gas light is at the present time the cheapest; and it has come out the victor in the hard competitive fight for supremacy between gas and electricity. Gas light has by no means been put in the background by the electric light, as was generally thought it would. Both rivals are still hopeful, and it is just this fight for supremacy that is causing such rapid progress. There is no reason why the gas light engineer should lose courage, for the consumption of gas since 1859 has increased twenty fold; then, 40 million cubic meters were manufactured, while today more than 800 millions are produced.

Though the petroleum light has had to yield in many cases to the electric and gas light, it is still the source of light used by the small consumer, and as long as it holds this position it will be of great importance.

Next to electric light, the acetylene light gives the most beautiful illumination; it is cheaper than the electric incandescent light, but as yet it cannot compete with the petroleum light, or with the incandescent gas light.

The electric incandescent lamp has become very popular in spite of the uneconomic conditions it presents, which may be taken as a hint that there is a great demand for a small electric lamp suitable for interior illumination. Gas light engineers tried to drive out the larger electric light sources by means of compressed gas lamps, etc., and the electrical engineers answered it by bringing a high efficiency arc lamp on the market; and again chemists and electrical engineers, and even the inventor of the incandescent gas light himself, have endeavored for years to produce an electric incandescent lamp that is more economical.

The carbon filament incandescent lamp could not be driven out by the many different new incandescent lamps, in spite of its high consumption of current. The Nernst lamp, that was so very promising because it consumes only half as much current, resists high temperatures and is easily connected, is too expensive to make on account of the rheostat and coil required to heat up the glowers, and is not durable enough, especially when exposed to shocks.

The osmium incandescent light, which is, like the Nernst lamp, still being improved upon, also has the disadvantage of a high cost of production, besides requiring too low a voltage—not more than 47 v. With the usual voltage at the mains these lamps have to be placed in series and always several together, or especial arrangements have to be made to divide the voltage. Though it has been said that the voltage has been increased so that two lamps can

be burned, this can be accomplished only by an increase in the cost of production. The current consumed is 1.5 watts per candle, or half that of a carbon filament lamp, which lasts as long as the osmium lamp, if not longer. Compared with the Nernst lamp it has the disadvantage of having to be placed in a hanging position, because the hoop-shaped osmium filament softens on becoming incandescent and then it bends until it breaks.

The tantalum lamp consumes about the same amount of current as the osmium lamp, but, unlike the latter, it can be burned on 110 v. circuits, on account of its long filament, and it may also be placed in any position. It may even be assumed that the tantalum lamp will be made for higher voltages also. The useful life is from 400 to 600 hours, with a total life of over 1,000 hours. It requires careful protection from shocks, and more so after it has burned for a while than when new; the filament then breaks easily, and though the ends solder themselves together on coming in contact with each other and the lamp continues to burn, the filament becomes finally so short that it cannot stand the overheating. On the other hand, because the specific resistance of tantalum increases with increasing temperature, the tantalum lamp is not as sensitive to changes in voltages as the carbon lamp. It gives out a white light that always remains the same, just as the osmium lamp. Another, though less important, advantage is the fact that the luminous surface is larger and more equally distributed over the lamp than in the case where the lamp has only one or two loops.

The intensity of the tantalum lamp changes in a much smaller degree with the voltage than that of the carbon filament lamp, though others claim that the difference is small. Acording to Ambler an increase in voltage of 4 per cent. causes the light to increase by about 24 per cent. in the carbon filament lamp, but only 9 per cent. in the tantalum lamp; and in order to cause the same change of intensity in both lamps it is necessary to raise the voltage twice as high for the tantalum lamp as in the carbon filament lamp. For every two per cent. increase in voltage the light of the carbon lamp is increased by 11 per cent., and that of the tantalum lamp only 5 per cent. This is easily explained by the positive temperature co-efficient of tantalum and by the negative one of the carbon. The same increase in voltage causes, on account of the increase of resistance, a smaller increase in temperature in the tantalum than in the carbon filament lamp.

The lower cost of production, 25 marks (62c.) and the higher terminal voltage, give the tantalum lamp the preference over the osmium lamp, and it would have met with good success if it had not been for the latest zirconium and Wolfram lamps.

According to the statements of the manufacturer himself, zirconium lamps burn with one watt per candle, and the average life is at least 500 hours. For the time being they are manufactured for voltages as high as 110, the price of the 40 volt lamp is 3 marks (about $0.75), that of 75 volts 3½ marks (87c.) and for 120 volts 4 marks ($1.00).

Gulcher's iridium lamp is manufactured only for low tensions (to 24 volts); the price for a 12-24 volt lamp is 3½ marks (87c.); they burn with 1-1.5 watt per candle. Publications of the results of the measurements and experiments as to its life are not yet ready.

The very latest metal filament incandescent lamp is the Wolfram lamp, which is being manufactured by four different firms in four different ways.

The first group of manufacturers are using the patents of Just and Hanaman. They intend to make a standard type of 30-40 Hefner candles for 110 volts and 1.1 watt per candle; they even expect to reduce it to 0.8 watt per candle. These lamps gave in the laboratory of the Munich municipal plant from 38.9 to 45.7 HK., with an efficiency of about 1.1 watt per HK.

The manufacturer of the Kuzel lamps, Kremenecky, in Vienna, states the economy of the lamps of about 19-32 v. to be about 1-1.25 watt, with a useful life of 1,000 hours, in which the average decrease of light was not more than 10-15 per cent. from the light intensity in the beginning. It is said to burn through very seldom, and in case the filament breaks it is soldered again by itself and the lamp continues to burn.

According to a government test in Vienna, 32-30 v. Kuzel lamps have burned with an average economy of 1.06-1.12 watt per HK. Their life was 1,000 to 1,490 hours, respectively, while the decrease in light at the end was 1.6 per cent. to 4.5 per cent., respectively, from the original tension. According to the tests made by the Austrian Purchase Association the 55 v. lamp had 31 HK and 1.1 watt per HK in the beginning of the test, and after 917 hours 28.6 HK and 1.185 watt per HK, which is equal to a decrease of light of 7.6 per cent. within 917 hours. I also hear that these lamps are going to be put on the market for 110 v. The cost of production will be relatively small and the new lamp will be out next season.

The current consumed by a 3-ampere Hewitt lamp is 0.33-0.15 watt per candle; this is about the best result obtained by flaming arc lamps. With reference to the constancy of illumination and the steadiness of burning the mercury vapor light has not yet been surpassed, especially since considerable changes in voltage have no effect. But the principal advantage of the

mercury lamp consists in the fact that it needs no adjustment and no attention, and that the illumination remains constant, according to the tests made so far. If the Hewitt lamp is well treated it has an excellent life. Lamps that are still in a good condition have lasted 7,000 hours and more. The price of a mercury vapor lamp, inclusive of all that belongs to it, 75 cm. long for 500-600 standard candle light, is, in America, $30.00; and Heraeus' quartz lamp, that consists of a very expensive quartz glass which allows the ultraviolet rays to pass, costs, with switch connections, $75.00. Schott's uviol lamp 25 cm. long with support is about $31.00. The fact that the bluish-green color with its disagreeable effect prevents the general use of the mercury lamp, as has already been mentioned.

The Wolfram lamps, also called osmium lamps, that are manufactured in Vienna by the osmium concern, have also been tested in the laboratory of the Munich municipal plant, and they gave at 110 v. 54.7-55.6 HK and 1.026-1.047 watt per HK.

The technologic museum in Vienna found 6 osmium lamps to have an efficiency of 1.03 watt per HK, and after 1,776 hours of burning 1.09 watt per HK. The company intends to manufacture osmium lamps of 40, 50 and 60 HK for 105 and 110 v.

The life of the osram lamp of the German Incandescent Gas Light Co. is given by the manufacturer to be 1,000 hours on the average, and no decrease of light intensity is said to take place. According to a test of the government laboratory 32 c.p. lamps still showed an increase of intensity of light of about 2 per cent. after they had burned 500 hours, while the 25 c.p. lamps had not lost 1 per cent. The specific efficiency of the 32 c.p. lamps was 1.12 watt per HK, and 1.08 watt per HK for the 25 c.p. lamps.

The Auer company intends to produce also osram lamps for 220 v. and 40-50 HK with an efficiency of 1.2 watt per HK, as well as lamps of 50-200 HK and 1 watt per HK. The life of these lamps is said to be 1,000 hours on the average, with absolute constancy of light. The osram lamp can be used for continuous as well as alternate current, and costs about 4 marks ($1.00).

Whether the new Wolfram lamps are going to satisfy all expectations can only be said after it has undergone a thorough test in practice. It is best to wait for developments of all the new kinds of metallic filament lamps as they are as yet only in a state of laboratory development or in a condition of preparation for production. It is, therefore, surprising to frequently see reports in the daily press about metallic filament lamps, according to which we are going to have lamps with a specific efficiency of 0.5 watt per HK. Every expert knows that a 1 watt lamp means an immense progress, and it seems better to give the Wolfram lamps a chance before urging our inventors on to new efforts. In order to prevent a standstill in electrotechnics on account of too rapid a development it is best to go at a moderate pace.

The necessity of using the new lamps in a vertical position downwards, which, by the way, is the one favored by the horizontal illumination, might be called a weakness when compared to the carbon filament lamp, but, has not lately the inverted light conquered new fields for incandescent gas lighting, fields that were thought to be reserved for the electric incandescent light?

As already remarked, several inventors are producing Wolfram lamps, but it must be understood that, in those countries that test a patent as to its originality, as in Germany and Austria, with the exception of the first application of Just and Hanaman, not one of the many applicants succeeded. Hence it cannot yet be said which of the different processes is going to be protected by an effective patent, nor is it possible to say which process will put out lamps that are the best for practical purposes.

Now, it is interesting to ask: Which one of the lamps will drive out the others and remain alone on the field as the victor? Is it electricity, illuminating gas, petroleum, acetylene, or alcohol? Brilliancy is arraigned against low price, and convenient application against the inconvenient and restricted. It is safe to say that for the time being no one will have the field alone, because it is too large to be satisfied by any one, and if a few new kinds should be called into existence, they too could live.

Whether we are ever going to have an electric incandescent lamp of ½ watt per HK efficiency is a question that cannot yet be answered; but such a lamp would certainly mean a great progress in electricity, the influence of which on the development of illumination cannot be estimated. Until now, illumination by electricity is still a luxury; then the electric incandescent light, if using only ½ watt per HK, would become as cheap as the incandescent gas light, provided the price at present charged for electric energy (about 40-50 pfennigs per KW.-hour), remains the same. If such a lamp should become popular, the demand for electric energy would, of course, be greater, which is equivalent to saying that the price will be lower; and furthermore, it will affect the development of electric plants, compared with which their present state might be called a modest beginning only.

THE OSRAM LAMP

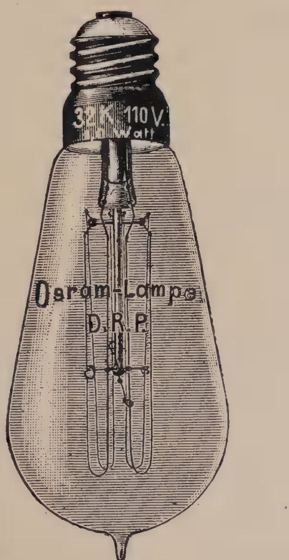
Electrotechnische Zeitschrift (Berlin), Aug. 9.

The Osram lamp, made by the German Incandescent Gas Light Co. (Auer Gesell-

schaft), Berlin, was first brought before the public in May, 1906, on the occasion of the meeting of the society of the German electrical engineers at Stuttgart, and at the general convention of the Association of Electrical Manufacturers in Lindau. It aroused widespread interest, but details could not be given at the time, because the patent had not yet been granted, and a report of the Osram lamp without details appeared as having no value.

The Osram lamp (see Fig. 1) has been made on a large scale ever since this spring, at first for 32 and 50 candles and for 100 to 130 volts. The efficiency of the lamp is about 1 watt per Hefner candle. Its average life, according to tests made by the Reichsanstalt (government testing laboratory), and from the results of actual use, is about 1,000 hours, during which there is scarcely any diminution of light.

The Osram lamps put on the market at the present time have to be burned in a



vertical position, but it may be confidently expected that they will be made so as to burn in any position, as has already been shown by the installation of a few hundred lamps exhibited at the meeting of the Society of German Electrical Engineers in Stuttgart; the Osram lamps were placed there in all kinds of positions.

The average watts consumed during the whole life of the lamp does not undergo any considerable change, as may be seen from the diagram. To test the length of life the Reichsanstalt picked out from a large number eight samples of about 25 c.p., and a like number of about 32 c.p. It was prescribed to test them with an alternating current from the mains of the municipal plant of Charlottenburg, so that they might be exposed, just as in practice, to all kinds of changes of voltage. The test of the 25 c.p. lamps was made to establish the

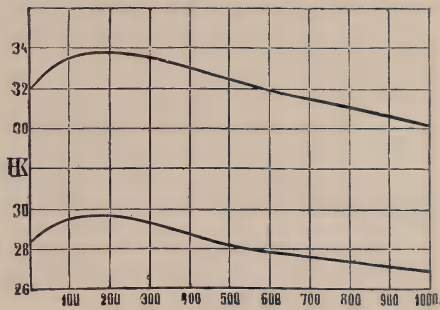


FIG. 1.

capacity and quality of the producing process, since it is much more difficult to produce lamps of low light intensitv and

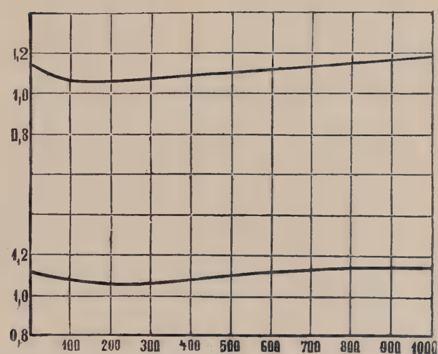


FIG. 2.

high efficiency for the higher voltages. While, for instance, lamps of 16 c.p. at about 70 volts may be produced without

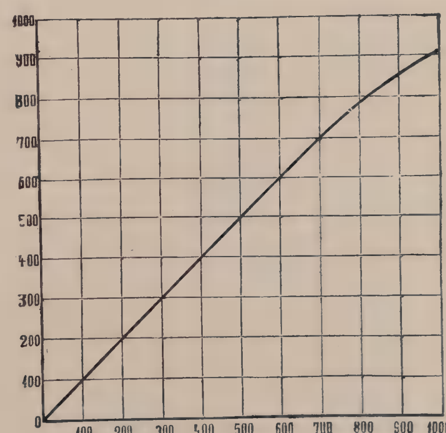


FIG. 3.

difficulty for 1 watt per Hefner, still giving an excellent light constancy and life, it is very difficult to make them for 110 volts and above for the same watts and the same intensity. The same is true for carbon filament lamps; they are made of good quality, for instance, for 16 c.p. 110 v., while 16 c.p. lamps for 220 v. are not as good.

The test showed that the average decrease of light intensity of the 25 c.p. lamps during the first 1,000 hours was 6.3 per cent., and of the 32 c.p. lamps 3.6 per cent. The maximum and minimum decrease for the 25 c.p. lamps was 11.4 and 4.2 per cent., respectively, in the case of the 32 c.p. lamps, 6.1 and 0.6 per cent., respectively.

Figure 1 represents the change of illumination of the two kinds of lamps. The mean decrease of light calculated from the start is, for the 25 c.p. lamps, after 1,000 hours, about 6.3 per cent., and for the 32 c.p. lamps, after 1,000 hours, 3.6 per cent.

In Fig. 2 the two lines show the change in the efficiency with reference to the Hefner candle.

The line in Fig. 3 shows the influence of the lamps burned out before 1,000 hours had passed on the average useful life. It may be seen from this line that though a few lamps burn out sooner, this has no influence on the average useful life on account of the durability of the others.

The test report of the Reichsanstalt shows that of the 16 tested lamps 11 were perfectly uninjured after they had burned 1,000 hours; it appears, therefore, that the average life is more than 1,000 hours.

The practical tests have shown that it is immaterial for the length of life of an Osram lamp whether it is run on an alternating current or continuous current; but to prevent the idea that the length of life of an Osram lamp might not be as favorable on an alternating current as on a continuous current, the Reichsanstalt tested the lamps on an alternating current, from which we may see that the Osram lamp is very suitable for alternating currents.

It may yet be pointed out that by introducing one watt lamps for higher voltages the distribution of electrical illumination, similar to gas illumination with the Welsbach mantle, has been considerably advanced; for the saving by means of the Osram lamps as compared with the carbon filament lamps that are generally used is 70 to 75 per cent., according as lamps of 110 or 220 v. are compared.

To give an illustration, it may be mentioned that with the price of the current at 50 pfennigs (12½ cents) per kilowatt hour, and an average length of life of the carbon filament lamps of 500 hours, and of the Osram lamp of 1,000 hours, a 50 c.p. Osram lamp does not cost any more than a 16 c.p. carbon filament lamp; and that under the same conditions a 32 c.p. Osram lamp against a 16 c.p. carbon filament lamp, although giving 100 per cent. more light, still saves 1-3 of the expenses in 1,000 hours of burning. In this calculation the expenses for the substitution of the Osram lamps are taken as 4 times as high as in the case of the carbon filament lamps.

The Osram lamp will be delivered regularly after September, 1906, while the larger interests are receiving them now, in order that they may be thoroughly investigated. The price for the Osram lamp will be finally settled in September; until then it will be sold for 4 marks (the price of the Auer-Os lamp).

As was shown by the installation of a larger number of high voltage lamps on the day of the convention, the Osram lamps may also be made for higher voltages and intensities than 130 v. Good and durable lamps have been successfully made for 220 v. and 40 to 200 c.p. that have, by a consumption of energy of about 1.25 and 1 watt, respectively, in lamps above 75 HK, the same average length of life and light constancy as the 110 v. lamps. Further, lamps of 200 c.p. may be made for voltages of 110 to 130, and such lamps will be ready this fall. The reason for not beginning to deliver the 220 v. lamps is, though the Osram lamp is made on a large scale already, because the demand for the 110 v. lamps that are easily produced could not be met, if at the same time the 220 v. lamps, that require a longer time for production, would have to be manufactured. Not until the Osram lamp is manufactured in its new building will they be produced in such a way that making of high voltage lamps may be taken up.

THE FRINGE OF PHOTOMETRY

By H. Leicester Greville, F.I.C., F.C.S.

Journal of Gas Lighting (London), August 21, 1906.

The "Fringe of Photometry" may seem a somewhat curious title to "point a moral or adorn a tale." Nevertheless, it may be possible on consideration to see that the estimation of the real available illuminating power of gas is but feebly defined by even the most scientific methods of official testing. There can be no finality as long as, ignoring modern developments, the photometrical value of gas is to be defined by methods of developing light on the basis of the limited combustion of so-called luminous hydrocarbons. Ever since the introduction of the development of light by incandescence, the older system, founded on luminous hydrocarbons, should have taken, using colloquial language, "a back seat." Why this has not been duly recognized is no doubt the fault of the natural conservative instincts which prevail in this country, and which, however useful in the way of politics, must always be regarded

as disastrous to the progress of science.

If we refer to the history of the introduction of gas as an illuminant, we find that the discovery that by the treatment of coal in a certain way it was possible to convey a means of furnishing light through pipes at a long distance was a distinct revelation. The only competitor was the candle of the commonest description; even paraffin lamps were in those days an unknown quantity. A source of light which could be brought from a distance free of carriage, was so distinctly new that it is little to be wondered at that at this early period a simple jet of flame which replaced the light of the average candle should not have been welcomed. The question of the possibilities of cooking by the use of coal gas were in those days probably never thought of. From the initial stage of the introduction of gas up to the present time there has been a development unprecedented in any known industry; but the trend of the progress of gas manufacture has made it more and more exigent that certain conditions should be laid down between the producer and the consumer. For the purpose of the present article, it is simply proposed to consider the matter of illuminating power.

We have had two most valuable papers recently read on the question of the development of light from gas—viz., those by Mr. Charles Carpenter* and Mr. W. R. Herring.† The Carpenter burner solved the vexed problem of dealing with all qualities of gas with the use of only one burner. This was necessary from the maintenance of the old regulation of fixing the gas consumption to a 5-feet rate. Possibly, however, this was better than the alternative of prescribing different burners for varying qualities of gas. The absurdity of the whole thing is this—viz., the prescription of the burner to be used for testing by Act of Parliament, that it should be available for use by the consumer. I do not sympathize with Mr. Carr in his remarks on Mr. Carpenter's paper; but there is no doubt that no scientifically constructed test burner of a high grade would or could ever be used by the general public, if they had any brains.

On this point of the question, Mr. Herring's paper affords most valuable evidence. His communication is of a scientific character, and is published in a scientific journal. Unfortunately, the information does not therefore reach the ear of the general public who represent the average gas consumer. It is to be regretted that the man of science cannot as a rule write so clearly as to place scientific progress within the knowledge of the commonalty, and that the average journalist, conspicuous in literary acquirements, is so misleading in his facts when he intrudes on the borderland of science.

Reverting to the question of gas, What is the value of this at the present day to the consumer? A pure question of price in proportion to value received. What does this depend upon? Two questions—the maximum light he can obtain, apart from any test burner, and the heat he can obtain for cooking purposes. How are these measured now for the protection of the consumer? The value of his gas for cooking depends on its capacity for developing heat. On this point there is no parliamentary definition. On the question of light, when an average consumer can buy a burner of the incandescent type for about 8d. to 1s., why should he go to the expense of a scientifically constructed test burner at a much higher price, and with the disadvantage of the constant breakage of chimneys? What the efficiency of the Carpenter burner is, I have no knowledge. We can, however, take Mr. Herring's paper as to the value of the incandescent burner. I refer to Table "C." The incandescent burner gives a value of about 31 candles per cubic foot of gas. The equivalent value of the most modern test burner would not probably exceed 4 candles at the very outside. Further comment is superfluous. Another point is shown by Mr. Herring, and one which I recognize as most valuable—that in spite of considerable variations in the candle-power of gas as determined by the No. 1 argand, the light afforded by a good incandescent mantle per cubic foot, with a proper regulation of gas and air supply, is practically constant. Tested in this way, the light development does not seem to be altogether a function even of heat.

The average gas consumer should as soon as possible be made to understand that it is within his power to get a 31-candle light from a single foot of gas. He or she wants to be shown that in gas there is available a source of both heat and light which can be obtained at a cheaper rate than even any municipal supply of electricity. A house may be wired for the supply of electricity; but there is no official guarantee that the charge for current shall afford any equivalent to the consumer even in the matter of light. On the simple domestic detail of boiling a kettle of water or cooking a rasher of bacon, electricity is hopelessly at a discount as compared with gas. Official bodies who are ever eager to place the most stringent conditions on gas companies, withdraw the local policeman where electricity rules supreme, and extract money with a bland smile from the pocket of the unfortunate ratepayer to make up for deficiencies in unsuccessful electrical undertakings.

Enough as to this. As the consumer can now obtain (say) upwards of 150 candles from the combustion of his 5 feet of gas,

*"Journal," Vol. XCIV., p. 886.

† See *Ante*, p. 316.

which is officially recorded as some 13 to 16 candles, the pertinent question arises as to what is the true illuminating power of any particular gas. Are we not, in adhering to the older methods of testing, simply hovering round the fringe of the matter? Again, even with Mr. Herring's lengthy experiments, finality has not been reached. It is recognized, rightly, that, even with the incandescent mantle, there are questions which have not as yet been thoroughly threshed out. The best development of light is presumably the relation of the mantle to the gas, taking into consideration a properly adjusted air supply; but we have as yet to know the relations of luminous and calorific values, flame temperatures, and flame volumes, which conduce to the highest possible results. We know that the use of a mantle enables us to obtain a brilliant light from an otherwise non-luminous gas. We know, too, that the calorific intensity of the flame is one of its most important functions; also that the shape and volume of the flame should be so adapted to the mantle as to bring all portions of the latter to maximum incandescence.

With the full recognition of the possibilities of gas lighting by incandescence, we shall slowly but surely drift into the supply of gas of lower (official) illuminating power, with mutual advantage to both consumer and producer. I read in the last number of the *Journal* Mr. R. Bruce Anderson's able presidential address before the Irish Association of Gas Managers, in which he states that he is making some experiments in the direction of the supply of low-grade gas. I quite endorse his general views on the subject. He puts the matter tersely when he says: "The guiding bargains struck between consumers and companies were made long before the days of incandescent lighting, and subsequent ones have merely followed, on stereotyped lines, as fresh Acts or Orders have been passed." I shall be glad to hear of the result of his experiments on what he facetiously terms "stretched gas." The subject is of great interest. As a final allusion to the papers of Mr. Herring and Mr. Carpenter, I am glad to find a graceful recognition in both cases of the services rendered them by their respective scientific experts.

INDIRECT ILLUMINATION OF SCHOOLS

Electrotechnik und Maschinenbau.

Experiments were recently made in Munich to determine the cost and relative advantages of indirect illumination for school and draughting rooms. The arc lamp was found to give the best results, but intensifying gas burners more economical. This method of lighting has been strongly recommended to the school authorities.

SUGGESTIONS FOR A UNIFORM SYSTEM OF ESTIMATING STREET ILLUMINATION AND METHODS FOR ITS CALCULATION

By L. Bloch, Berlin.

From the *Electrotechnische Zeitschrift* (Berlin), May 24, 1906.

I. The Estimation of a Street Illumination.

We are accustomed in engineering in general, and especially in electrical engineering, to measure all work done in exact figures. In street illumination alone we depart from this, and are satisfied to say simply that the street is well, fairly or badly illuminated. The reason for this may be that no definite understanding has as yet been reached as to a scale by which street illumination is to be expertly judged. All kinds of proposals in this respect have been made for years. As early as eleven years ago, Prof. A. Blondel gave five points to be considered in estimating street illumination in his treatise, "Public Lighting by Arc Lamps."

This question of street illumination has recently received a great deal of attention, especially in English reviews, and it proves most annoying to have no method of uniformly judging it. The judging of street illumination by uniform methods is at present all the more urgently required, especially as new varieties of illumination are being steadily introduced.

The first question to be discussed is, in what manner we can best judge the quality of street illumination. Not only should this be done by using the smallest number of quantities, but they should also enable us to first make our calculations, and then the measurements, in the simplest way possible.

1. Horizontal or Vertical Intensity.

The figures in question must refer either to the horizontal intensity, *i. e.*, the brightness on a horizontal plane in lux (meter-candles), or the vertical light intensity, *i. e.*, the brightness on a vertical plane in lux. If we regard it as the main purpose of street illumination to enable us to recognize objects on the ground, or to read a letter or a map of the city, etc., then the horizontal intensity is to be considered; if, however, we wish to be able to distinguish, for instance, the faces of approaching people, the vertical intensity is to be taken into consideration. Both points of view are of equal weight; hence other reasons must decide it. But the horizontal intensity has the decided advantage because it gives in all places on the ground only one single value; while vertical intensity may have several entirely different values for the same place, according to the direction in which the vertical plane faces. The face of a person may be very brightly illuminated

if it is turned towards the next lantern; but if that person should turn his back towards the lantern his face might no longer be distinguishable, although he still remains in the same place, since the other lanterns are comparatively far away from him. Hence the vertical intensity is not suitable for judging street illumination, as it gives no single value; it is better to neglect it, since when the horizontal intensity is sufficiently great, there is also sufficient illumination with respect to vertical intensity. The claim that electric illumination gets the better of the bargain if we judge by horizontal intensity, and that it is better for gas illumination if the vertical intensity is preferred, is not true.

If for this reason the acceptance of the horizontal intensity is to be advocated, the new question arises, whether the horizontal intensity at the level of the street, or at face height, *i. e.,* 1.5 m. (5 feet) above ground, is to serve for judging the illumination. While the first is to be taken into consideration for distinguishing objects on the ground, the latter is correct for reading, etc. But since it is almost always difficult to measure the intensity on the ground, and simpler to do so at a height of 1.5 m., it is, in my opinion, the best to consider the horizontal intensity 1.5 m. above ground as the right one for estimating street illumination.

2. MEAN HORIZONTAL INTENSITY.

The brightness of any kind of street illumination is unequally distributed over the street surface, the horizontal intensity varying between a minimum and maximum in the different places on the surface of the street. Neither the maximum nor the minimum value gives the right idea of the quality of the street illumination. If we should accept the highest value we could place the lamps very low in order to obtain high maximum values, while the other values might still be insufficient. On the other hand, the minimum value of street illumination that is otherwise good might be greatly lessened on account of the shadows caused by trees, etc.; besides, the minimum values of most street illuminations are so small that they cannot come near a comparison and cannot even be measured with most photometers in use. The correct standard for judging street illumination is the mean horizontal light intensity E_m. Strictly speaking, this value is

$$E_m = \frac{1}{F}\int E\,d\,F = \frac{\Phi}{F}$$

in which E is the horizontal light intensity in the separate places of the street surface 1.5 m. above ground, and F is the whole street surface to be considered. The integral value corresponds with the whole flux of light that reaches the plane F. E_m will approach

$$E_m = \frac{\Sigma\, E . f}{\Sigma\, f}$$

where f is the area of a small plane and E the horizontal light intensity in the center of it. If all these small planes are made of equal size and if their area is taken as a unit, and if besides the whole plane F is divided in z such units, then is

$$E_m = \frac{\Sigma\, E}{z}$$

This integrating or summation of a larger number of separate planes may probably at first not agree with the application of the mean horizontal intensity; but it can be done quickly and still sufficiently accurate if the number of the separate planes taken is not too high, or it may be altogether replaced by suitable methods of approximation, as is intended to be shown below.

3. UNIFORMITY OF ILLUMINATION.

While the mean horizontal intensity affords a standard for the real intensity of street illumination, we can also obtain a measure for uniformity if we find the ratio of the maximum and minimum values to the mean horizontal intensity. The nearer this ratio comes to unity the more evenly distributed is the illumination. It is especially important that the proportion of the minimum to the mean horizontal intensity should not be too small, as otherwise the illumination will always show "dark spots." The proportion of the maximum to the mean horizontal intensity, however, does not have to approach unity so closely. There are conditions even where it is desirable to have some places especially well illuminated, though for the rest the illumination might not be sufficient; one is at least able to read or to distinguish things plainly in such places.

Accordingly, street illumination is to be judged in the first place by the mean horizontal intensity, and also by the uniformity of the illumination. The thing next in importance in all street illumination is, of course, the steadiness of the light, and its color; and finally, the efficiency, *i. e.,* the ratio of the expense to the illumination attained, which may be measured exactly in figures by the aid of the value of the mean horizontal intensity, is of special importance.

II. THE CALCULATION OF STREET ILLUMINATION.

1. THEORETICAL BASIS.

It must be possible to find the mean horizontal intensity, which is of fundamental importance for judging street illumination, quickly and in a simple way for all actual cases. How this may be done will now be shown, first in a special case, and then in general for actual cases.

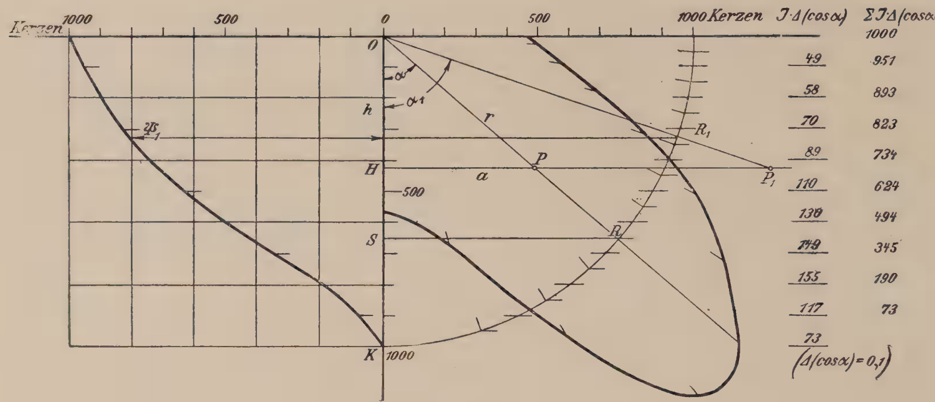


FIG. I.

Imagine a lamp suspended over the center of a circular plane of a radius of a, meters, at a height of h meters above the measuring plane, *i. e.*, 1.5 meters from the ground. The lamp has a light distribution as shown in figure, right hand side. If we wish to determine the c.p. intensity I for and point P in the measuring plane, at a distance a from the foot of the lamp post, from the curve of distribution, we have to lay off from O the curve of light distribution the height $h = O\ H$, and perpendicular to it $H\ P = a$; the c.p. intensity I may then be read off from the curve of distribution on the hypotenuse $O\ P$. The horizontal intensity E for point P may now be found from the equation

$$E = \frac{J.\ \cos\ a}{r^2},$$

in which

$$a = \sphericalangle\ H\ O\ P$$

and

$$r = O\ P = \sqrt{a^2 + h^2}.$$

Since the value of a and h are given, and

$$\cos\ a = \frac{h}{r},$$

it is best to calculate E from a and h alone; thus

$$E = \frac{J\ .\ h}{\sqrt{a^2 + h^2}^3}.$$

Having found E for a number of assumed for h. For Fig. 2, h was taken as of horizontal intensity (Fig. 2), which, however, is only good for the value assumed for h. For Fig. 2, h was taken as 8.5 meters, equivalent to a height of suspension of the lamp of 10 meters above the ground. If we now want to find the mean horizontal intensity for a circular plane of a diameter, we have to divide this plane into a number of concentric circles and calculate the area of each one of them; as for example, for the segment of the circle that lies between an and an + 1 in Fig. 2, thus, $f = \pi\ (a^2 n + 1 - a^2{}_n)$.

This area is to be multiplied by the mean light intensity of the circular segment, and the sum of all the separate products is to be found. Then, by dividing this sum by the total area $\pi a_1{}^2$, we have the mean horizontal intensity.

As has been shown by J. Zeidler in his book entitled "The Electric Arc Lamp," we can obtain the mean horizontal intensity for any arrangement of lamps, and for any plane in street of square, in the manner just described; and the work may be still further simplified by the use of unit curves.

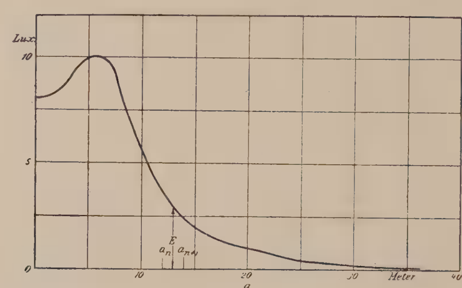


FIG. 2.

Prof. A. Blondel also shows by examples how to calculate the mean horizontal intensity on a plane of any shape whatever; for that purpose he uses in place of the light intensity that portion of the flux of light that is distributed over the separate circular segments for the calculation of the total flux of light that reaches the street surface, and then derives the mean horizontal intensity according to the definition given above, by dividing by the total area of street surface.

In spite of the simplifications already introduced, it appeared to me that the methods thus far given were still too compli-

cated for practical calculations of the mean horizontal intensity; and this induced me to search for a still simpler process, which I will describe—first for circular planes, and then its general application to any plane.

2. SIMPLIFIED METHOD FOR CALCULATING THE MEAN HORIZONTAL INTENSITY ON CIRCULAR PLANES.

According to the definition given above for the mean horizontal intensity

$$E_m = \frac{1}{F}\int E\,d\,F = \frac{1}{F}\int_0^{a_1}\frac{J\cos a}{r^2}\,d\,F.$$

In this expression we may substitute (see Fig. 1)

$$r = \frac{h}{\cos\alpha}$$

$$d\,F = 2\pi\,a\,d\,a = 2\pi\,h\,\mathrm{tg}\,\alpha\,d\,(h\,\mathrm{tg}\,\alpha)$$
$$= 2\pi\,h^2\frac{\sin\alpha}{\cos^3\alpha}\,d\,\alpha.$$

which gives

$$E_m = \frac{1}{F}\int_0^{\alpha_1}\frac{J.\cos^3\alpha}{h^2}\,.\,2\,\pi\,h^2\,\frac{\sin\alpha}{\cos^3\alpha}\,d\,\alpha$$

$$= \frac{2\pi}{F}\int_0^{\alpha_1} J\sin\alpha\,d\,\alpha = \frac{2\pi}{F}\int_0^{\alpha_1} J\,d\cos\alpha$$

$$= \frac{2\pi}{F}\sum_0^{\alpha_1} J.\Delta(\cos\alpha).$$

The integral value for Em contained in this formula coincides with the well known expression for the mean hemispherical intensity (J_0) if we put instead of the upper limit of the integration a, the value $\frac{\pi}{2}$ Hence the value of the integral may be obtained in the same way as the mean hemispherical intensity.

$$J_0 = \int_0^{\frac{\pi}{2}} J\sin a\,.\,d\,a,$$

The proceeding is as follows: To find the integral value for the curve of light distribution, as shown in Fig. 1, we draw a quadrant from the point O with a radius $O.K=1$. (For actual cases it is best to choose $O\ K = 1\ dm$). We can then obtain on the vertical axis $O\ K$ the cos. a for every angle a, if we project the point of intersection R of the hypotenuse $O\ P$ with the circle, to S upon the vertical axis $O\ K$. Then

$$O\ S = \cos\ a,$$

since $O\ R = 1$.

If we divide $O\ K$ into 10 equal parts each of them is

$$\Delta\ (\cos\ a) = 0{,}1.$$

For the angles a that correspond to the center of each separate part, the light intensities that belong to them have been taken from the curve of light distribution. By multiplying these values with

$$\Delta\ (\cos\ a) = 0{,}1.$$

we get

$$J.\ \Delta\ (\cos\ a).$$

for each of the ten parts, and these values have been entered in Fig. 1 with the parts to which they belong. We get from the addition of the separate values from bottom to top

$$\Sigma\ J.\ \Delta\ (\cos\ a).$$

These values also are entered in numbers on the right hand side of Fig. 1 and on the left side at the end of the corresponding segments as ordinates above $O\ K$ as the axis of absissas. By connecting the points of the ordinates we obtain a curve, which we will call hereafter the curve of light flux, because every value of the curve is proportional to the flux of light within the area of the angle corresponding to it. Then the quantity

$$\Phi = 2\,\pi\int_0^{a_1} J\ d\ \cos\ a$$

represents the flux of light within the area of the angle O to a_1.

The curve of flux is the same is the integration of the so-called Rousseau diagram. Consequently the ordinates of the curve of light flux must give the mean hemispherical intensity of the curve of distribution belonging to it.

The curve of flux having been found in the manner described, we lay off, in order to obtain Em for a circular plane of radius a_1, perpendicular to

$$O\ H = h$$

the value.

$$a_1 = O\ P_1$$

from this we obtain the angle to be considered

$$a_1 = \sphericalangle H\ O\ P_1.$$

If now the point of intersection R_1 of the hypotenuse $O\ P_1$, with the segment of the circle drawn, with the curve of light flux, we get in the same way the value sought

$$\Psi_1 = \int_0^{a_1} J\ .\ d\ \cos\ a$$

and if

$$F_1 = \pi\ a_1^2,$$

then the required mean intensity is

$$E_m = \frac{2\ \pi\ \Psi_1}{F_1}.$$

The process here described has the advantage that we have to find only once a curve of flux from the curve of distribution, and then the value Ψ. may always be taken from the same curve for all lamp heights h and radius a_1, from which we can easily find the mean horizontal intensity. Also, if we use lamps of other intensities, but of the same kind of distribu-

tion, we may still use the same curve of flux and all we have to do is to find, from the value taken from it, values in proportion to the light intensities used. It is a good idea to make normal curves of flux and of distribution for a certain round number of candles for the kind of lamps that are frequently used. For instance, the curve drawn in Fig. 1 represents the normal curve of flux and distribution for an ordinary arc lamp with a globe of opal glass, of 1,000 candles mean horizontal intensity.

If we do not have to find the mean horizontal intensity, as has been assumed so far, that is, if it is given, as well as the area of the circular plane F_1, that is to be illuminated, we can obtain for it, according to the above deduction

$$\Psi_1 = \frac{1}{2\pi} E_m \cdot F_1.$$

From the radius a_1 of the plane F_1 and the given or assumed height of the lamp h we get, as above, the area about the angle a_1 that is to be illuminated; and from the normal curve of light flux the value of Ψ that belongs to it of a mean hemispherical intensity of 1,000 candles. From the proportion of the calculated value Ψ to the value Ψ already found for 1,000 candles, we get the intensity required for the lamp to be employed.

In the formula for the mean horizontal intensity

$$E_m = \frac{2\pi}{F} \int_0^{a_1} J \cdot d \cos a$$

the height h of the lamp does not occur, it is true, but is contained in it indirectly. Namely, if we have to illuminate a circular plane F that always remains the same the area about angle a_1 constantly decreases as the height of the lamp increases. Since the flux of light decreases also in every case with the decreasing area about the angle, we can see that the mean horizontal intensity must also decrease in every case as the height of the lamp increases, entirely independent of the kind of distribution of the lamp to be used. But by increasing the height of the lamp the uniformity of the illumination is improved, and accordingly its requirements are also sufficient to determine the height of the lamp.

3. CALCULATING THE MEAN HORIZONTAL INTENSITY FOR ANY AREA OF STREET OR SQUARE.

The case here fully discussed of a single lamp in the center of a circular plane that serves to illustrate the simplified process does not ever occur in practice. In reality we have to do with a larger number of lamps that have to illuminate all sorts of planes, of streets as well as of squares. To find the distribution of the illumination and to calculate the mean horizontal intensity we can divide the plane that is to be illuminated into a number of equal squares or right triangles, and calculate for the center of each the intensity there. For that purpose we have to find the distance of the center of each square from lamps that are still to be considered for the illumination of these points, and then take from the curve of intensity (Fig. 2) the intensity that belongs to the separate distances. By adding the values of the single lamps we obtain the intensity for the center of each square. If we add all the intensities thus found and divide the sum by the total number of the squares we obtain the mean horizontal intensity. This rather complicated process may be simplified, since, on account of the existing symmetry, we have to take into consideration only a small part of the whole area to be illuminated. For example, there are four usual arrangements of lamps on streets and squares, those parts being divided into squares for which the calculation of the intensity is to take place. In the other parts of the area of street or square the distribution of the illumination found repeats itself again and again symmetrically or periodically. It is best to make the number of single squares or triangles about 10 or 20, in order to obtain on the one hand sufficient exactness, and on the other hand work that does not require too much time.

It is best to use this method when the mean horizontal intensity is to be found from the results of measurements of existing street illuminations.

If, however, in projecting a street illumination, the mean horizontal intensity is to be first calculated for different cases, then even this method is too complicated. We can get to the point much quicker by another method which may be applied, as we shall now show, to any kind of lamp arrangement whatever. For that purpose we introduce in the calculation as F_1 the area of the street that is illuminated by one lamp, and assume this plane to be a circle in whose center the lamp is placed and that it is illuminated by this lamp alone.

These suppositions introduce two sources of errors into the calculation: the area of the street that corresponds to the lamp is generally of the shape of a right triangle; by transforming such a right triangle into a circle of the same area the parts that lie within the circle, or places of less by places of greater intensity. On account of this error we should get too high a value for the mean light intensity. On the other hand, the illumination that comes from the neighboring lamps is not taken into consideration, which gives rise to an error that has the effect of making the calculated mean intensity come out too small. These

two errors are more or less counterbalanced, and there remains generally only a slight error.

In case of street illumination the remaining error depends chiefly on the ratio of the distance of the lamps to the width of the street; and it may in all cases be limited at the most to 5% if we multiply the mean horizontal intensity found by a correcting value k. This correcting value has been found from a rather large number of examples for different distributions and different lamp arrangements. If h is the ratio of the distance of the lamps to the width of the street,

$$k = 1. - 0.1\,\lambda$$

The distance of the lamps is always to be measured in the direction of the street, also, in a transposed arrangement of the lamps, on both sides of the street.

If F_1 represents the area of the street illuminated by a given lamp, then the mean horizontal intensity for all actual cases of street illumination is to be calculated thus:

$$E_m = k \cdot \frac{2\,\pi\,\Psi_1}{F_1}.$$

The application of the approximation method we will now illustrate by an example: A street 18 meters wide is to be illuminated by arc lamps that are suspended above the middle of the street at a distance of 48 meters, and 10 meters above the street surface, which is 8.5 meters above the measuring plane. Let the light distribution and the light intensity of the lamps correspond to the curves in Fig. 1. The area of the street F illuminated by a given lamp is then $48 \times 18 = 864$ cubic meters. This area is equal to the circle of 16.6 meters radius. For $h = 8.5$ and $a_1 = 16.6$, we get in Fig. 1 the angle a_1 and its value $\Psi_1 = 675$ candles in the manner as described above. We get from the distance of the lamps and the width of the street

$$\lambda = \frac{48}{18} = 2{,}7$$

and

$$k = 1{,}2 - 0{,}1 \cdot 2{,}7 = 0{,}93.$$

Then—

$$E_m = 0{,}93 \cdot \frac{2\,\pi \cdot 675}{864} = 4{,}55.$$

By exact calculations by means of dividing the street surface to be considered into 18 small right triangles $Em = 4.40$ was obtained. Hence the simple approximation method almost coincides in this case with the exact method, the difference being only 3.5%.

Also in the calculations of the illuminations of squares the value for Em as obtained by the proposed method brought nearer to the true value by the correcting value k. For h is then substituted the ratio of the mean distance of the neighboring lamps to the greatest length of the square. The errors are then, in most cases, also only 5% at the most, and only in exceptional cases as high as 10%, as has been proved by several examples. Therefore, the approximation method here given may be used in general for the calculation of the mean horizontal intensity of streets and squares with any kind of lamp arrangement, as well in the case the c. p. and the arrangement of the lamps are already given and a mean horizontal intensity to be calculated afterwards, as when the required intensity and the arrangement of the lamps are given and the necessary c. p. of the lamps is to be found. For the latter case the procedure is as above. If, however, besides the intensity, the c. p. of the lamps to be used has already been determined, and it is required to find the necessary distance and number of lamps, it is best to proceed in the indirect way, by figuring backwards from a certain assumed distance, whether the required mean intensity has been obtained by the stated c. p. and light distribution of the lamps. On account of the simplicity of the procedure several repetitions of such a trial calculation requires only a short time. It is to be kept in mind that this process is an approximation process in which the aggregate errors for all actual cases do not amount to more than 5%. Since, however, we cannot be very particular with regard to the c. p. of such street lamps, we can neither be strict with regard to the intensity, and the application of an approximation method for its calculation is therefore fully justified.

4. ILLUMINATING SYSTEMS CONSISTING OF SEVERAL LAMPS.

If several lamps are suspended from one post or combined in one lantern, they can be treated in the calculations for the intensity as a single light-source. Though the manner of the light distribution is sometimes changed by the combination of several lamps, it may still be accepted substantially in most cases as the same as that of the single lamp. But a certain amount must be deducted from the sum of the candle powers of the single lamps, since they obstruct each other's light, and hence do not act with their full power. In the literature of gas illumination the amount to be subtracted is given as 12% for two burners, and 17% for three burners, in one lantern. Similar amounts will also have to be subtracted from electric arc and incandescent lamps. If several incandescent lamps are combined in one lantern in different positions, with the application of a reflector, then, of course, not only does the

c. p. change, but also the light distribution, which is then to be taken up separately for calculations of illumination.

5. CALCULATING THE UNIFORMITY OF ILLUMINATION.

If there are certain requirements to be fulfilled by the uniformity of illumination it is necessary to find, besides the mean, also the highest and the lowest horizontal intensity. The highest value of the intensity is to be taken from the illumination curve (Fig. 2), that must be drawn for the height of the lamp in question. Only where the distances of the lamps are very small are the intensities of the neighboring lamps to be considered from the calculations of the highest value.

The point in the street that is to be taken into consideration for minimum value of intensity must be the one at the greatest distance from the neighboring lamps, and it may easily be found; from the distances of the point from the neighboring lamps we can find the minimum intensity by means of the illumination curve (Fig. 2). If the requirements for uniformity of illumination (ratio of the highest and the lowest values to the mean horizontal intensity) are not satisfied, we either have to increase the height of suspension of the lamps, or, in case the mean intensity is then no longer sufficient, to decrease the distance between the lamps.

6. ECONOMY OF ILLUMINATION.

The economy of street illumination may be represented by the efficiency, or gas consumed, for each lux of mean horizontal intensity, and for each square meter (or probably better practically 100 square meters) street surface, just as the economy of a light source is represented by the efficiency, or gas consumed, for one candle. By means of the efficiency thus calculated we can easily compare the running expenses of different kinds of street illuminations. Further, if we have found the cost for a number of street illuminations, we have a convenient way to quickly find the aggregate cost for a newly planned street illumination if the area to be illuminated and the required mean horizontal intensity are given.

CONCLUSION.

It is the purpose of this article to show above all that street illumination may be judged in a more general, hence simpler, way; and it would be very desirable to reach some kind of an agreement through a discussion opened by these propositions. It was further intended to show how to make it possible in the simplest way to make the calculations of street illumination thus estimated. Though the consumer will have to depend on the calculations of the engineer rather than on his own opinions, it is, in my judgment, of advantage to both parties.

AUXILIARY APPARATUS FOR DETERMINING MEAN SPHERICAL AND HEMISPHERICAL CANDLE POWER

By Dr.-Ing. Berthold Monasch.

Electrotechnische Zeitschrift, Berlin, July 19, 1906.

Auxiliary apparatus by means of which we can find the mean spherical intensity by a single photometric measurement was first described by Blondel. He called such an apparatus a "Lumenmeter," and described three different constructions in 1895 in an extended treatise. In these three cases the source of light was placed in the center of an opaque globe that allowed the light to pass through one or more openings; the light was thrown upon a screen after one or several reflections, and was then photometered as an original light-source. The disadvantage of Blondel's "Lumenmeters" is, besides its high price, its restricted application; it can only be used for light-sources that are axially symmetrical if the spherical intensity is to be determined by a single measurement.

Matthew's "integrating photometer" can also be used only for axially symmetrical light-sources, and for those axially asymmetric ones that may be put into rapid rotation, as, for instance, filament incandescent lamps.

In the year 1900 Ulbricht ("Etz," 1900, page 595) described an apparatus that consisted of a hollow globe having a diffuse reflecting surface on the interior and an opalescent glass window in its surface which was photometered as an original light-source. Ulbricht's apparatus is preferable on account of its low price, which, for the same radius, is about one-fourth that of Blondel's "Lumenmeter." Numerous photometric laboratories are using it under the name of "globe photometer."

The name "globe photometer" does not seem to be well chosen. By "photometer" we understand in general an arrangement through which the eye compares the flux of light that radiates from a standard with that from the source to be investigated. But the indirectly illuminated opalescent glass window in the Ulbricht globe is a secondary light source which has to be photometered by another photometer. Because the appellation "Lumen" expresses the meaning of light flux, Blondel calls this class of apparatus "Lumenmeters." But in this name the word "meter" gives us the idea that the apparatus itself represents the measuring arrangement, which is not always true; and if the apparatus carries the measuring arrangement itself, it consists again of a known photometer. These devices are then only auxiliary apparatus. The Ulbricht apparatus will therefore be called in the following discussion "the Ul-

bricht globe," and considered as belonging to the class of integrators. Ulbricht gave a supplement to the theory and application of his globe in a second treatise.

Integrators are usually understood to mean auxiliary apparatus for ascertaining the mean spherical intensity. Although the mean spherical intensity alone is sufficient in constructing different kinds of light-sources, so far as the transforming of electric energy into light is concerned, it is of little value to the illuminating engineer, since he has to produce, in the case of street lighting, an illumination in a given plane, and the mean spherical intensity is the mere statement of a light flux (c.p.), the spherical distribution of which he does not know. The misunderstanding of the meaning of spherical intensity has also led to the erroneous idea that if the mean spherical intensity of an arc lamp is 400 HK, for instance, the mean spherical light intensity of two such lamps (that are usually placed at a distance of 30 to 50 meters from each other) is 2 x 400 = 800 HK—a mistake that may frequently be noted in the comparisons of the efficiencies of lamps connected two or three in series.

The mean spherical flux of light is in the case of many light-sources, not equivalent to the flux that is really utilized. For the illumination of closed rooms, in which it is most frequently required to have not only a good floor illumination, but also an illumination of the walls and sometimes also of the ceiling, the mean spherical flux coincides very often with the ultilized flux. However, the application of arc lamps for inside illumination is restricted, partly on account of a demand for light-sources of lower intensities, and partly on account of the competition of incandescent lamps, Nernst lamps, osmium lamps and tantalum lamps.

The principal field of the arc lamp is outside illumination; for instance, street illumination, illumination of public squares, and outside illumination of show windows. In this kind of illumination only that flux is utilized that radiates into the lower hemisphere. Though the whole globe of an arc lamp for street illumination is in most cases brightly illuminated, and attracts the eye from afar, the lower hemispherical flux only can be utilized for a street illumination. The upper hemispherical flux of light is lost for real street illumination. But since it is less the purpose of arc lamps for street illumination to dazzle the eye of the passer-by, and to illuminate free of charge the rooms of people on the upper floors of buildings than to give the strongest and most equally distributed illumination possible on the area underneath the lamps, or objects in that area, the utilized flux of lamps for street illumination coincides with the mean lower hemispherical flux. It has therefore become the rule in illuminating engineering to state the mean hemispherical intensity for arc lamps for outside illumination, if the statement of the spherical intensity has not been especially required. Only to give the highest light intensity, as has been done as recently as 1905 by a foreign carbon firm, evidently for dishonest purposes, is abusive.

Although the mean hemispherical intensities are not of much value to the illuminating engineer for the predetermination of illumination without a knowledge of the curve of distribution, the locating of which requires much time and care, it may still be of value in some cases, especially if it can be found quickly by a single measurement.

It was, therefore, of great importance that Bloch ("Etz," 1905, page 1047) proved that it is possible with the Ulbricht globe to measure also the hemispherical intensity if the point of light is brought within the surface of the globe itself.

According to the theoretic deductions of Ulbricht and Bloch, it is possible to use the Ulbricht globe also for ascertaining the mean spherical intensity of light-sources that are axially asymmetric.

As is well known, we distinguish in the illuminating technic light-sources of regular and of irregular shapes. Regular shaped light-sources are those in which the luminous point sends the same light intensity in all directions; its photometric form is a globe. Such regular shaped light-sources may for practical purposes be substituted with slight difference of effect by carbon filament incandescent lamps, if the filament is arranged suitably, and if provided with a good diffusing globe.

The irregular shaped light-sources are divided into axially symmetric and axially asymmetric sources. Those light-sources are axially symmetric that produce a different intensity at every point of the meridian circle drawn through a vertical axis from the point of light as a center, while all points on circles perpendicular to the axis receive equal illumination. In the case of the axially asymmetric light-sources every point on a circle perpendicular to the axis is differently illuminated. To the axially symmetric light-sources belong some incandescent lamps, according to the arrangement of the filament, and arc lamps in which the carbons are placed one above the other, the axes of which fall in a straight line. Axially asymmetric light-sources are some incandescent lamps, and arc lamps in which the electrodes are side by side.

It is now to be investigated whether, by the diffusing process in the globes, a single measurement in any place on the surface of the globe is sufficient to determine the mean spherical or hemispherical intensity of light-sources that are strongly axially asymmetric. Though Ulbricht has made

an axially asymmetric light-source by screening off an incandescent lamp on one side, this case does not exactly correspond to those that are most met with in practice. Bloch investigated in his Ulbricht globe of 1 meter diameter a continuous current lamp of high efficiency of strong axial asymmetry, but he has given the difference in the adjustment of the photometer for the extreme fluxes of light only in scale form, from which it is impossible to see how large the real change of the mean spherical intensity was, since the value of the light intensity was not given in the scale. Since the committee on photometry of the Society of German Electric Engineers and the Association of Electric Manufacturers are going to recommend (which has since been done) the Ulbricht globe for measurements of the intensities of arc lamps, it seems necessary that further explanations on this point be made public. To determine whether the axial asymmetry of light-sources in the globes is done away with at the measuring window, the illumination by indirect light at different places on the meridian of the globe is measured, and then the light-source turned so that the same meridian is illuminated from another side of the light-source. If the illumination is the same in all the separate points of a meridian by indirect light, then the globe may be conscientiously recommended for determining the mean spherical or hemispherical intensity of axially asymmetric light-sources by a single measurement, provided we are as careful there as in using integrators. Before taking up measurements, we will discuss briefly the construction of the globes.

CONSTRUCTION OF THE GLOBES.

Globes of glass may be made with diameters as large as 70 centimeters; but since it is desirable in the photometry of arc lamps fitted with globes to use globes of larger diameters, it is necessary to make them of another substance, such as metal. The Ulbricht globe, which Ulbricht himself described, had a diameter of 0.5 meter, the Ulbricht globe that Bloch described, a diameter of 1 meter; later Corsepius has also described another form of construction (see ILL. ENG., page ——). Both consisted of sheet iron, and each was composed of two hemispheres that could be taken apart for cleaning the inside surface. The metal hemispheres are made by pressing by hand. If we wish to make globes of larger diameter than 1 meter we cannot form the globe of hemispheres that have been thus pressed by hand, since the production of the pressing material becomes expensive for a hemisphere of 1.5 meter diameter, and such a globe of sheet iron of 1.5 meter diameter would have to be stiffened for mechanical reasons. It is best, therefore, to build globes of larger diameters than 1.5 meters from a frame of rings covered with sheet iron. The globe shown in Fig. 1 was built in this manner and has a diameter of two meters. It carries two openings for observations, placed on two meridian circles perpendicular to each other that diverge with a 10-degree angle at the center. While observations are made through one opening the other openings may be closed by shutters. The upper half of the globe may be put on, and rolled away from the under half. From the upper part of the globe an opening having a diameter of 50 cm. may be provided, and covered with a lid.

It is especially difficult to choose the material with which to coat the inner surface of the globe. It must give a perfectly diffuse reflection, and adhere firmly to the support. Prof. Dr. W. Wedding recommended the use of barium sulphate and water for a binding means; it is also suitable for glass globes with rough inner surface. But if it is attempted to coat smooth surfaces with barium sulphate and water it is possible to get a homogeneous coating, but on touching it with foreign bodies, as with the hands of the observer, the color comes off, which causes a change in the constant of the apparatus. The barium sulphate, as well as most other dead white substances, such as zinc oxide, magnesium oxide, etc., curdles when mixed with most organic liquids, and cannot be used at all for coating. By using water glass as an adhesive it is possible to obtain a firmly adhering coating, but, after a certain time, it peels off, especially when several such coatings are put on and when exposed to the heat of arc lamps. Ulbricht used chalk with water glass, but on one made according to his directions this peeling off of small areas of the diffuse reflecting layer could be noticed after it had been used for some time.

The author found finally after much experimenting that "zapon" lacquer is the suitable adhesive for barium sulphate. The viscous mixture of barium sulphate and lacquer sticks as well on metal as on glass, is perfectly matt, and becomes, if the barium sulphate is carefully ground, almost as fine as powder. If the metal surface that is to be coated is very smooth it is recommended to first put on a coating of boiled linseed oil with copal varnish. A surface particle on which light is thrown must, if the surface gives a perfectly diffused reflection, appear as an original light source, and the light intensity that radiates in a certain direction from a surface particle as a secondary light source must be, according to Lambrecht's law, in direct proportion to the cosine of the angle of radiation.

In order to test the coating in the globes several surfaces of sheet iron were coated with different coatings and then illuminated through a slit with a pencil of light that fell perpendicularly upon the surface, using a Nernst lamp as primary light source; the

light intensities radiating in the different directions as from luminous surfaces were then measured. In Fig. 2 two cases are represented. The left part of the figure gives the relation of the light radiation from the illuminating area to the angle of radiation, obtained with a homogeneous coating of zapon lacquer and barium sulphate, in a plane perpendicular to the luminous area, and shows that the diffuse reflection follows Lambert's law with sufficient accuracy if the ray lies in the perpendicular plane. The right part of the figure shows the behavior of a surface coated with the same mixture, but in which there were crystals of about ½ mm. diameter; it may be seen that such an unevenness may cause considerable irregularities in the diffuse reflection.

Since a globe of large diameter is very expensive, hard to manipulate and occupies much space, the question arose whether a hemisphere could not be used for measuring the mean spherical or hemispherical intensity.

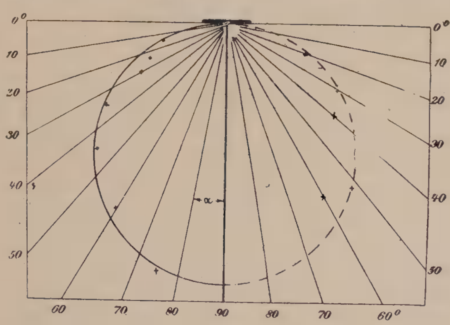


FIG. I.

If the surface of the light-source to be investigated is brought into the center of the largest circle of an open hemisphere, the plane of the equator of which is horizontal, then the lower hemispherical flux of light is sent into the hemisphere. Each point of the inside area of the globe that is coated with a diffuse reflecting coating sends, according to Lambert's law, light in all directions. Let the light radiation of the points PKA on the surface of the hemisphere along the circle of the meridian PAB be represented by a small circle in Fig. 3. It may be seen from this that, besides the direct light that comes from the light source L, there is also indirect light sent from each point on the surface of the globe to all other points on that surface; and it is now easy to prove that only the illumination caused by indirect light, as for instance of the point P, is in direct proportion to the mean hemispherical intensity. Since the mathematic proof compared with Bloch's deductions ("Etz," 1905, p. 1047), gives no new characteristics, with the exception of the differences in the integration limits, it need not be repeated here. But it may also be observed that a part of the light flux issuing from the surfaces of the particles are sent directly into the open and is lost for the illumination of the surface of the hemisphere. For instance, from point A the light flux within the angle PAB reaches the open after the first reflection, and from the point B that within the angle PKB. The loss to the illumination of the surface of the hemisphere by the opening is shown by a change of the constant of the hemisphere as compared with the constant of the whole globe with the same coating.

If we understand by the constant of the apparatus that value with which the observed illumination of the window is to be multiplied in order to obtain the mean hemispherical intensity, then the open hemisphere will give an increased constant.

In the treatise of 1905 and 1906 ("Etz," 1906, p. 50) Ulbricht recommended for the measurement of the hemispherical intensities globes from whih the lids have been lifted; the point of light is to be adjusted in the center of the circle formed by the opening. If we make the diameter of opening equal to the diameter of the globe, the open hemisphere is then a special case of the Ulbricht globe without the opening.

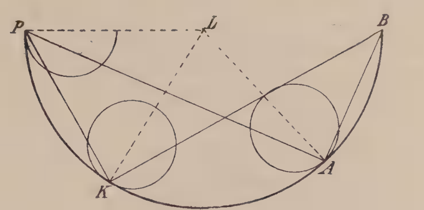


FIG. 2.

The hemisphere is preferable on account of its simple construction and its easier manipulation. If the light-source is let down into the hemisphere to a depth such that the whole flux of light from the source reaches its surface we can then measure the mean spherical intensity also in the hemisphere.

However, for practical purposes it is not recommended to use the hemisphere, because reflections caused by the light issuing from the hemisphere against armatures, walls, or from a ceiling of black photometering room even, may easily exist, and have an effect on the surface of the hemisphere, thus making the measurements inaccurate.

(*To be continued.*)

The Commercial Engineering of Illumination

NEW LAMPS AND NEW OPPORTUNITIES

By Francis W. Willcox.

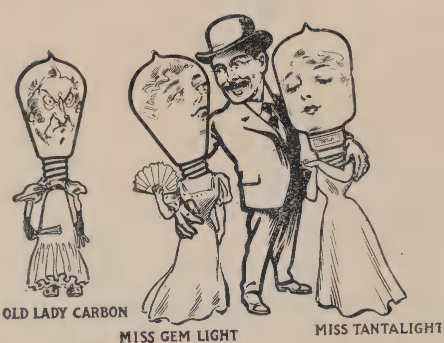
Read before the Ohio Electric Light Association at Its Twelfth Annual Convention, Held at Put-in-Bay, Ohio, August 21, 22 and 23, 1906.

The present period marks a most important development for the electrical industry. The limitations of the ordinary carbon filament incandescent lamp have been removed through Dr. Whitney's discovery of metallizing or graphitizing carbon. This has given a practical lamp of 2½ watts per candle without any loss of life over the present 3.1 w.p.c. lamps and the promise of still greater gains.

The discovery and utilization of certain new metallic substances for filaments gives a practical lamp of 2 watts per candle in the Tantalum lamp, and possibly still higher efficiencies in other lamps under development.

The GEM or metallized filament and the Tantalum lamp are now both on the market at prices far below their value to consumers, and stand ready to give the aid central stations have long required and desired from higher efficiency incandescent lamps.

So then, gentlemen, we have before us an opportunity not a theory—a very pressing, practical and important opportunity,



"OFF WITH THE OLD AND ON WITH THE NEW."

which is the immediate adoption of these higher efficiency lamps and their introduction into service to replace present incandescent lamps (now obsolete) as rapidly as it is possible to obtain them.

This movement should not be deterred by the possibilities of still higher efficiency lamps to come, for the incandescent lamp is a renewal device of low cost and must be replaced by one of its own kind or something better. Exchanges can, therefore, readily be made to improved types without any sacrifice such as would be involved in the case of apparatus like Nernst lamps and arc lamps. On the contrary, the immediate adoption of the present improved lamps is a necessary step to enable central stations to more readily pass on to

"THE CHANGE TO HIGHER EFFICIENCY LAMPS IS LIKE A COLD PLUNGE—MOST BENEFICIAL IN ITS REACTION."

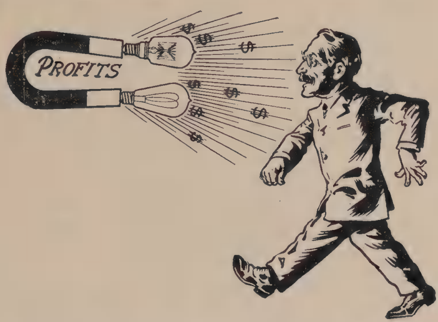
whatever better lamps there are to come, and thus gradually adjust their conditions and income to the new improvements, step by step, instead of by one large jump.

Neither should the movement be deterred by the fear that higher efficiency lamps may cause an immediate reduction of income. Act as promptly as a company may, they will hardly be able to introduce the new lamps fast enough to cause any *immediate* material reduction of income, and the improvement in business resulting from the adoption of the new lamps will offset any tendency towards income reduction.

The change from the present to the new lamps can be compared to a cold plunge. It involves some decision and vigorous action, but the beneficial re-action and results amply repay the effort. An instructive parallel is also found in the fact that a full dive insures quicker results and greater benefit than a slow dip.

Let no central station attempt half way measures or lose the prestige of having first introduced and supplied the new lamps to their consumers. The central station must be an eager and willing leader in such matters and not a constrained or hesitating follower. It should be the first to promote its consumer's interests and not allow this to be done by the supply dealer. The new lamps cannot be shelved—the consuming

public will have them sooner or later, and with how much better effect and greater advantage it is for the central station company to supply them promptly, directly, and liberally, to their consumers. Of course, the change to higher efficiency lamps involves added costs and perhaps some temporary loss of income, but the change



THE ULTIMATE RESULT OF USING HIGHER EFFICIENCY LAMPS.

should nevertheless be definitely and decisively made. It is necesary to break eggs to make an omelet—no improvement is ever made without involving some sacrifices. Besides, it is not the immediate but the *ultimate* result that counts.

Now there should be no question as to the ultimate result if we can judge by experience. The introduction of higher efficiency lamps is the equivalent of a reduction in rates and the same effects should follow from each.

What does experience show results from reduction in rates intelligently made? Does it not show material growth of business and greater net earnings? This, at least, is the result that is stated to the writer. Electric service appears of recent years to have received its greatest impetus as a result of the adoption of low rates (made under new, profitable rate systems). An eastern manager in business for many years with an aggregation of lighting companies, told the writer that experience had demonstrated to him that more money could be made at reasonably low rates than at higher rates, and that the policy of keeping up rates which his companies had advocated and followed for many years, would be entirely reversed if they had to do it over again.

Let us look at the effect in a similar instance in the gas business. When the Welsbach mantle was first introduced, the gas companies were sore distressed and feared an extensive reduction of income. One of the largest gas combinations bought up the rights to the Welsbach lamp for this country, not because it wanted to introduce the improvement, but, on the contrary, that it might control and limit its use and thereby prevent any damage to the gas business. Most gas companies refused to have anything to do with the Welsbach lamps, and the improvement was frowned upon and discouraged. How different the result has been we all know, for this lamp, that the gas companies rejected, has become the corner stone of the gas business—has reestablished the industry and materially augmented income and earnings.

And similar results are bound to follow the adoption and introduction of higher efficiency lamps. Only let us learn from the gas companies' experience not to repeat their mistake of opposing the new lamps, but, on the contrary, to hasten their introduction and use in every way possible.

POLICY AND METHOD FOR INTRODUCING THE NEW LAMPS.

Before proceeding further, it will be desirable to describe the method of rating adopted for and values given by the new lamps.

The new GEM filament lamp has been standardized at 50 watts, thus giving the improvement in the form of an increase in candle power of 25%, or from 16 to 20 c. p., instead of a reduced wattage to 40 watts per lamp. The price of the lamp has been increased in the same proportion so that the renewal cost per candle hour per Kw. hour has not been changed. The following is an illustration of a sample of the new label:

SAMPLE OF NEW STYLE LABEL FOR THE GEM LAMP.

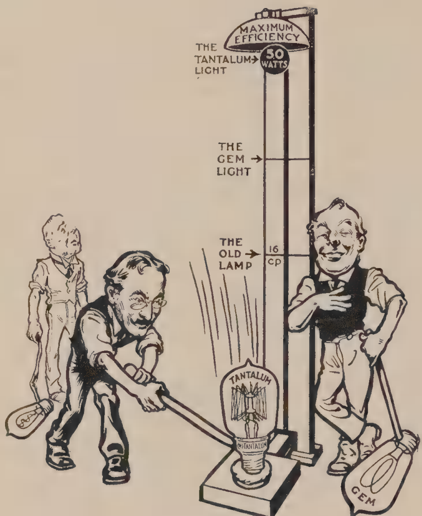
It will be observed that total watts is here substituted for the candle power rating heretofore shown on labels. This does not mean that candle power ratings or values will be abandoned; such a course is

FREE AND LIBERAL RENEWALS FOR THE NEW LAMPS IN DISPLACEMENT OF THE OLD.

not desirable nor possible even if desirable. Candle power values will continue to be used and referred to, but when given will be fully defined. As a lamp is capable of being rated in candle power in several ways, horizontally, spherically, downward values from varied forms of reflectors, etc., the omission of any candle power rating from label seemed desirable to avoid confusion.

After all, as electric metering is generally done on the Kw. hour basis, the practical unit is really watts per lamp instead of candle power. The plan has, besides, many advantages:

It allows even watt ratings per lamp, such as 50, 30, 20, etc., instead of the fractional ratings now existing on many sizes.



THE CENTRAL STATION MAN RAISES HIS STANDARD OF PERFORMANCE.

It insures a more uniform appearance and a more uniform performance of individual lamps by reason of the even degree of incandescence or efficiency at which a filament so rated will burn.

It permits central station to gradually advance their standard of efficiency from time to time to meet changing conditions.

Attention is called to the voltage markings arranged in a vertical column in steps of two volts apart. These voltages are known as the "top," "middle" and "bottom," or 1st, 2nd, and 3rd voltages (V_1, V_2, and V_3).

As is well known any one lamp will vary in its candle-power and watt rating with increase and decrease of voltage. The arrangement shown therefore permits three ratings for the lamp as shown in the table given below.

From the data given in the foregoing table each lighting company can determine what course it should adopt.

Central stations now using 3.1 w.p.c. lamps would naturally adopt the new lamps at full efficiency (top voltage) and thus keep their watt consumption per lamp unchanged. While the total cost of lamp renewals would be increased somewhat on this basis, the added charge is a small one to pay for the ability to give consumers 25% more light for the same revenue.

Central stations now using 3.5 w.p.c. lamps could opportunely adopt the new lamp in the middle or 2nd voltage. This would share the improvement with the consumer, giving 12% more light with 15% less wattage. The total cost of lamp renewals which are very low for the present 3.5 w.p.c. lamps—only about 1-3c. per Kw. hour, would be only slightly increased, and there is hardly a lighting company that could not profitably afford to make the change to at least this intermediate efficiency of the new lamps. Its useful life, 750 hours (with average life materially longer), is commercially sufficient as it is equal to that formerly given by 3.5 w.p.c. lamps. The life of 3.5 w.p.c. lamps is at present too long for the most economic service and could with advantage be shortened to correspond with that given by the new GEM lamp in middle voltage.

SUGGESTIONS AS TO RENEWALS.

If anyone doubts whether free lamp renewals is desirable, or if it is a well established practice, let him consult the 1906 National Electric Light Assn. Question Box on this point (pages 250 to 260). The answers to a number of questions on lamp supply and renewal policy, show overwhelming testimony in favor of free and liberal renewals. Indeed, practice goes much further in many instances and furnishes not only free lamps, but is now giving free signs to burn them in, and experience shows that this pays handsomely.

With the advent of the new GEM lamp, the importance of central station direction and control of the lamps used is greater than ever. Full and complete control is

TABLE OF VALUES OF GEM 50-WATT LAMPS AT 1ST, 2ND, AND 3RD VOLTAGES.

Voltage of Circuit.	Total Watts.	Mean Horizontal Candle Power.	Watts Per Candle.	Average Useful Life.
Same as "Top" or 1st Voltage (V1)....	50.	20.	2.5	450.
Same as "Middle" or 2d Voltage (V2).	47.5	18.	2.65	640.
Same as "Bottom" or 3d Voltage (V3).	45.	16.	2.8	940.

only obtained with free renewals, and the adoption of a free renewal policy (where not now in vogue) could therefore most opportunely be made with the introduction of the new GEM lamp. In any event, it is specially important that the new lamp

THE TANTALUM LAMP (½ SIZE).

should be favored with equally as liberal a policy as the present lamps.

Companies now giving free renewals of the present lamps should do likewise for the new lamp.

Companies now charging for lamps should supply the new lamp without any increase of price.

Unless the policy for the new lamp be at least as liberal as that for the present lamps, the introduction and general use of the new lamps is apt to be retarded.

THE TANTALUM LAMP.

At your last session you had the pleasure of hearing about the Tantalum lamp in the interesting paper of Prof. Ambler. Since then the manufacture of this lamp has been undertaken in this country and the lamp has been listed at a price of 75c. each or 60c. net in lots of 500.

The lamp is at present supplied in but one size—about 44 watts giving 22 mean horizontal c. p. (English Parliamentary Standard) and with a useful life on direct current of 700 to 800 hours. Unfortunately the life on alternating current is only about 1-3 of this value—too short to be commercial.

While the first cost (say 60c.) of this lamp seems high, if we pro-rate the useful life on direct current (750 to 800 hours) on an equal basis with that of the ordinary 3.1 w.p.c. carbon filament lamp, we find that it is reduced to about 40c. This is only about 25c. more than present 3.1 w.p.c lamps cost, and companies now supplying free renewals of the latter could furnish renewals of the Tantalum at 25c. each without any increase of renewal costs. This would give consumers the chance to use Tantalum lamps at no greater costs than are paid for a Welsbach mantle and thus place the electric service with the Tantalum lamp on an excellent competitive basis with Welsbach lamps.

TANTALUM UNITS.

The Tantalum lamp by reason of the relatively small end candle-power and the fact of their burning to better advantage in a vertical position, can be used to marked advantage in the form of a "Unit" with a suitable Holophane reflector. The accompanying illustration shows the Tantalum Unit combination lamp and reflector which you will notice is supplied uniform with that of the regular Incandescent Units with two types of reflectors giving concentrated and distributed distribution.

The following Table I. and Figure 3 gives the cost of an equal amount of light

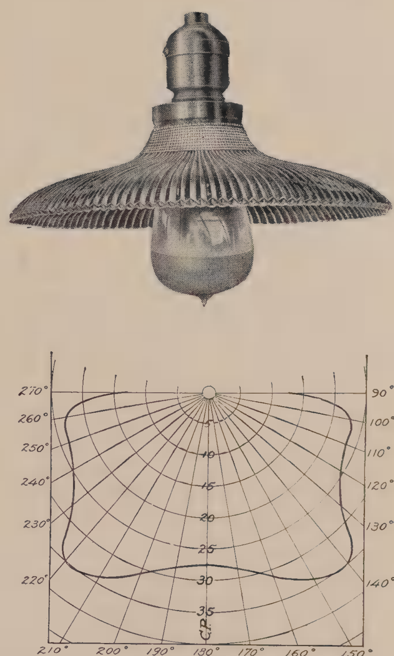


FIG. I.—TANTALUM UNIT AND CANDLE-POWER DISTRIBUTION WITH DISTRIBUTING OR D-T FORM HOLOPHANE REFLECTOR.

(1,000 candle hours) with Tantalum (at 2 w.p.c.) GEM filament (at 2½ w.p.c.) and ordinary carbon at 3.1 and 3.5 w.p.c., including cost of renewals in each case and power at various rates per Kw. hour shown.

TABLE I.

COST OF 1,000 CANDLE-HOURS OF LIGHT IN CENTS, INCLUDING COST OF POWER AND LAMP RENEWALS.

For Different Lamp Efficiencies at Various Rates per Kilowatt-Hour.

Rates per Kw Hour in cents.	Ordinary Carbon Lamp 3.5 W.P.C.	Ordinary Carbon Lamp 3.1 W.P.C.	GEM Lamp 2.5 W.P.C.	Tantalum Lamp 2.0 W.P.C.
1	4.5	5.1	4.5	5.
2	8.0	8.2	7.0	7.
3	11.5	11.3	9.5	9.
4	15.0	14.4	12.0	11.
5	18.5	17.5	14.5	13.
6	22.0	20.6	17.0	15.
7	25.5	23.7	19.5	17.
8	29.0	26.8	22.0	19.
9	32.5	29.9	24.5	21.
10	36.0	33.0	27.0	23.
11	39.5	36.1	29.5	25.
12	43.0	39.2	32.0	27.
13	46.5	42.3	34.5	29.
14	50.0	45.4	37.0	31.
15	53.5	48.5	39.5	33.
16	57.0	51.6	42.0	35.
17	59.5	54.7	44.5	37.
18	64.0	57.8	47.0	39.
19	67.5	60.9	49.5	41.
20	71.0	64.0	52.0	43.

TABLE II.

COST OF 1,000 CANDLE-HOURS OF LIGHT IN CENTS WITH FREE RENEWALS OF ALL LAMPS EXCEPT TANTALUM, FOR WHICH A RENEWAL CHARGE OF 25C. IS MADE.

Rates per Kw.-hour in cents.	Ordinary Carbon Lamp 3.1 W.P.C.	GEM Lamp 2.5 W.P.C.	Tantalum Lamp 2.0 W.P.C.
1	3.1	2.5	3.25
2	6.2	5.0	5.25
3	9.3	7.5	7.25
4	12.4	10.0	9.25
5	15.5	12.5	11.25
6	18.6	15.0	13.25
7	21.7	17.5	15.25
8	24.8	20.0	17.25
9	27.9	22.5	19.25
10	31.0	25.0	21.25
11	34.1	27.5	23.25
12	37.2	30.0	25.25
13	40.3	32.5	27.25
14	43.4	35.0	29.25
15	46.5	37.5	31.25
16	49.6	40.0	33.25
17	52.7	42.5	35.25
18	55.8	45.0	37.25
19	58.9	47.5	39.25
20	62.0	50.0	41.25

From these results it can be seen at straight costs per Kw. hour for current and an equal amount of light, just how the different lamps stand.

It should be noted that in spite of its high renewal cost, the Tantalum lamp gives the lowest cost of any of the lamps (at above 3c. per Kw. hour). With free renewals of ordinary carbon lamps and free renewals of GEM filament lamps and Tantalum lamp renewals at 25c. as sug-

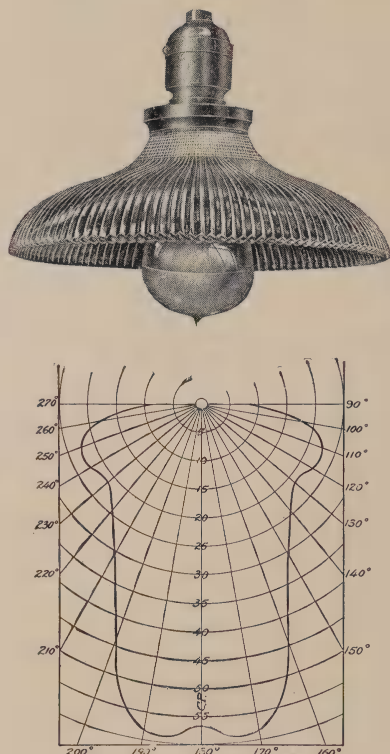


FIG. 2.—TANTALUM UNIT AND CANDLE-POWER DISTRIBUTION WITH CONCENTRATING OR C-T FORM HOLOPHANE REFLECTOR.

gested herein, the resulting cost for an equal amount of light at various rates per Kw. hour will be for the different lamps as shown in Table II.

THE GROWING PRE-EMINENCE OF THE INCANDESCENT LAMP.

The advent of these various improvements in lamp efficiencies directs attention to the growing pre-eminence of the incandescent lamp.

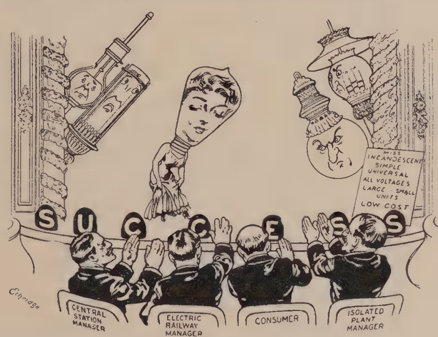
The incandescent lamp, by reason of its many well recognized advantages, must have the call over any other lighting device at anything near equal efficiencies or light-

ing costs, and there are many indications to the effect that the incandescent lamp is already making heavy inroads upon other lighting apparatus.

THE LOW INVESTMENT REQUIRED FOR AN INCANDESCENT LAMP INSTALLATION.

A most important advantage of the incandescent lamp is its low cost and the small investment required for an installation. Central station companies have learned from experience that electrical apparatus in which improvements follow each other as rapidly as they have in lighting devices, will be charged off and replaced in about five years, or even less time. How marked an advantage has an incandescent lamp in this particular—a small investment cost in the first place, and in the second place a ready and inexpensive exchange to improved types in the ordinary course of lamp renewals.

The argument does not lose its point because the customer may have bought and paid for the lamp—the burden of the relative heavy first cost of other lighting devices as compared to the incandescent lamp is just as great in its effect upon the electric lighting industry whether the consumer or the central buys the lamp.



THE INCANDESCENT LAMP IS THE FAVORITE.

The High Efficiency, High Candle Power Incandescent Units employing the GEM filament are excellent examples in point—providing central stations as they do with a simple effective, and highly efficient lighting device, at a very low cost—(1-6 of that of the Nernst lamp for an equal lighting value).

These Incandescent Units were described in my paper before this Association last year. Since then these Units have been widely and extensively used in all parts of the country, and have proven to be a most satisfactory and thoroughly practical and effective lamp for efficient illumination of stores, offices, and all interiors.

Marked improvements have recently been made in the life and candle power performance of the lamps, and this, together with the very low prices now made thereon, brings the renewal cost on a parity with the ordinary carbon filament lamp.

These lamps are rated on the new labeling plan already described by which the efficiency may be varied to suit different conditions and give satisfactory life. Thus using these lamps at the top voltage gives a life and renewal cost the same as for present 3.1 w.p.c. lamps; using them at bottom voltage gives a life and renewal cost the same as for present 3.5 w.p.c. lamps, and at middle voltage gives an intermediate life and renewal cost. The table below gives average values for "top," "middle" and "bottom" voltages.

One of the special advantages of these high candle power lamps in common with all incandescent lamps, is the ability to obtain practically any form of light distribution desired by simply changing the form of reflector. Thus two forms of Holophane reflectors are at present used with the Incandescent Units giving respectively a distributed downward and concentrated downward distribution of light.

THE NEW "BOWL" HOLOPHANES.

In addition to these two forms of reflectors another form known as the "Bowl" reflector (named from its similarity to an inverted bowl), has been introduced.

The various sizes of units equipped with "Bowl" reflectors are illustrated in Fig. 5. It will be noticed that the lines of the "Bowl" reflector follow the lines of the lamp more closely than in other forms of reflectors, and present, perhaps, a more graceful appearance. The "Bowl" reflector also hoods the lamp so well that clear glass lamps can be satisfactorily used—thus avoiding the loss of light (which is small) and the loss of life (which is large) of a frosted lamp. The curves of candle power distribution shown in Fig. 8 (page 19), are those given by clear lamps in the bowl reflectors.

These distribution curves are very interesting, and present some material advantages over those given with the present distributing and concentrating forms of reflectors.

With Voltage of Circuit the Same as	Per Cent. of Total Watts.	Per Cent. of Candle Power.	Hours Useful Life.
"Top" or 1st Voltage (V1)...........	100%	100%	450
"Middle" or 2nd " (V2)...........	96%	90%	640
"Bottom" or 3rd " (V3)...........	90%	80%	940

The light distribution given with the distributing reflector shown in Fig. 1 gives too much light sideways at angles of 10, 20 and 30 degrees from the horizontal, and its downward intensity is in consequence reduced. On the other hand the distribution from the concentrating reflector, Fig. 2, is perhaps too much downward and not spread enough for the average case. The distribution given by the new "bowl" reflectors is a happy compromise—the light is brought down and spread out. It is thus possible to obtain a practically uniform distribution over a wider area (equal to 1½ times the height of lamp above it) and of materially higher intensities than with the distributing form of reflector.

The following Table III. gives data as to height and distance between lamps with bowl reflectors for different degrees of illumination.

This gives the simple law that to obtain uniform illumination with "bowl" reflectors, the distance between lamps shall be two and a half times the height of lamps above the plane of illumination.

IDEAL ILLUMINATION.

In general lighting, uniform illumination is very desirable, as the eye can work comfortably with much lower intensities when the illumination is uniform than where it is not. The new "bowl" reflectors secure more nearly ideal results in this respect than any other reflectors or commercial lighting devices.

In Fig. 3 is shown the curve of Candle Foot Values to give uniform illumination and candle foot value curves of the Incandescent Units with Bowl reflectors and of the Nernst lamp. It will plainly be seen that the Incandescent Unit gives decidedly the best distribution. The following table (Table IV.) gives the values from which the curves in diagram, Fig. 9, are plotted:

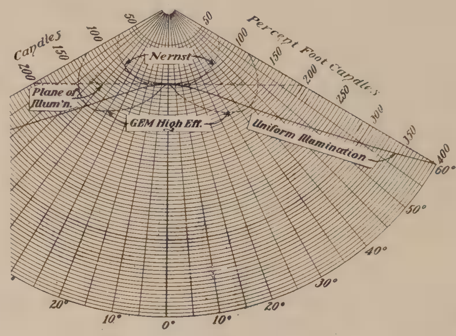


FIG. 3.—CANDLE FOOT VALUES EXPRESSED IN PER CENT. AND TAKEN NORMAL TO THE DIRECTION AT VARIOUS ANGLES FOR: I. UNIFORM ILLUMINATION; 2. GEM INCANDESCENT UNIT WITH "BOWL" REFLECTOR; 3. NERNST LAMP.

TABLE IV. (See Fig. 3).

CANDLE FOOT VALUES (EXPRESSED IN PER CENT. AND TAKEN NORMAL TO THE DIRECTION AT VARIOUS ANGLES) FOR, 1, UNIFORM ILLUMINATION; 2, GEM INCANDESCENT UNIT AND BOWL REFLECTOR; 3, NERNST LAMP.

Degrees Either Side of a Vertical Plane Through Lamp.	Per Cent. Values for Uniform Illumination.	Per Cent. Values Given by Gem Lamp and Bowl Reflector.	Per Cent. Values Given by Nernst Lamp.
0	100.0	100.0	100.0
10	103.0	120.0	107.2
20	113.2	140.0	103.0
30	133.3	155.0	98.4
40	170.4	160.0	93.3
50	242.0	150.0	85.8
60	400.0	120.0	74.2

TABLE III.

ILLUMINATION DATA FOR "GEM" INCANDESCENT UNITS WITH THE NEW "BOWL" HOLOPHANE REFLECTORS.

Class of Service.	Light Intensity in Foot Candles.	No. 2 Incandescent Unit 100 Watts. Diameter of Uniformly Lighted Area.	No. 2 Height of Lamp Above Area.	No. 2 Distance Between Lamps Where Two or More Are Used.	No. 3 Incandescent Unit 125 Watts. Diameter of Uniformly Lighted Area.	No. 3 Height of Lamp Above Area.	No. 3 Distance Between Lamps Where Two or More Are Used.	No. 4 Incandescent Unit 187 Watts. Diameter of Uniformly Lighted Area.	No. 4 Height of Lamp Above Area.	No. 4 Distance Between Lamps Where Two or More Are Used.	No. 5 Incandescent Unit 250 Watts. Diameter of Uniformly Lighted Area.	No. 5 Height of Lamp Above Area.	No. 5 Distance Between Lamps Where Two or More Are Used.	Watts Per Sq. Ft. of Area Lighted With Any of the Lamps.
Desk or	3	5.47	3.65	9.48	6.1	4.07	10.6	7.65	5.1	13.25	8.65	5.77	15.0	4.27
Reading	2	6.70	4.47	11.6	7.5	5.00	13.0	9.35	6.24	16.21	10.6	7.07	18.4	2.83
Table	1½	7.75	5.18	13.4	8.65	5.77	15.0	10.8	7.21	18.75	12.21	8.15	21.2	2.13
	1	9.46	6.32	16.4	10.6	7.07	18.4	13.25	8.83	22.9	15.0	10.	26.	1.41
General	¾	10.65	7.12	18.5	12.5	8.17	21.3	15.30	10.19	26.5	17.35	11.56	30.	1.055
Lighting	½	13.4	8.94	23.3	15.00	10.00	26.0	18.75	12.48	32.5	22.2	14.14	36.8	0.645

VALUE OF THE UNIT IDEA OF LAMPS AND REFLECTORS.

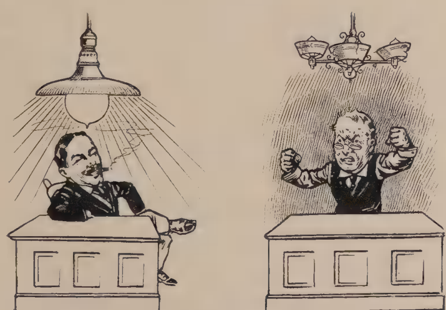
The plan of supplying a complete unit of lamp and suitable reflector has had a most beneficial effect in electric lighting service. It should never be forgotten that as much and more depend upon the efficient use of a lamp than upon the efficiency of the lamp itself.

To provide consumers with a scientifically designed reflector constructed to give the particular distribution required and which can be installed to give uniform illumination under a simple law—this is a long step in the betterment of electric lighting service.

Furthermore, it brings home the value and need of proper engineering in illuminating work. The omission of candle power from the new lamp label is significant in showing the tendency away from mere rated light value to the light effects—the illumination results. Heretofore the central station has only considered the lamp and its rated values, whereas desirable practice points to the lighting results given by the lamp as the important thing.

Heretofore the lamp has been installed and the resulting illumination left to be what it might. Correct service considers the illumination desired and selects and employs the lamp so as to obtain it.

Central Station companies must recognize that electric lighting work means mainly good illumination and must lay hold of methods that will achieve it in the most efficient manner.



"CENTRAL STATIONS MUST REALIZE THAT ELECTRIC LIGHTING WORK MEANS GOOD ILLUMINATION."

What a rattling of old chandeliers and fixtures and crashing of old shades and glassware all this means. The past five to ten years has been an era of central station reconstruction—of abandonment of old and obsolete apparatus for new and improved types. But what about your consumer's installations? Are not the same old ineffective types of fixtures and worthless old styles of shades still continued in service, and are they not in a large measure still continuing to go in to new installa-

"WITH THE NEW LAMPS COME NEW OPPORTUNITIES."

tions? If it is important to have an efficient and up-to-date station, how much more important it is (considering the lighting results to be obtained) to have efficient lighting installations? For it is upon the refined product, the delivered current at the lamp that we are dealing with at the consumer's installation, where 1% of improvement gives equal results to 10% improvement at the station.

Much work and study have been given to the elimination of losses between the station and consumer's meter, but how about the losses beyond the meter in the consumer's installation?

It is not too much to say that three-fourths of all the shades in use to-day with incandescent lamps are practically worthless in that they obscure and waste light instead of efficiently diffusing and distributing it. There should be a steadfast war waged against such useless relics. In the interest of good lighting service I have for years waged a campaign for lamp renewals, and now in the same interest I would wage one for the renewal of old worthless shades with new and efficient ones. Provide through proper illuminating engineering work for new installations, but do not stop there. Extend the good work to old installations as well, and aim to secure the highest efficiency not merely in the lamp but in the total illuminating results obtained.

Electric lighting installations must undergo a similar overhauling to improve lighting results and enable the electric light to withstand the improved conditions of gas competition. The introduction of higher efficiency incandescent lamps is the logical time to make this overhauling, and to induce customers in discarding their old lamps for the new ones, to also displace their old reflectors and fixtures with new and improved ones.

What has been and is being done in the gas business can be done in the electric business if only central station companies

will adopt a progressive policy on the lines indicated herein, and thereby reap the full advantages of the new lamps and the new opportunities.

And so, gentlemen, with the new lamps come new opportunities for the general betterment of the electric lighting service. The introduction of the new lamps is a most opportune time for central stations to inaugurate a progressive policy on lamps and lighting.

1st. To secure free renewals and promote a more liberal use of lamps.

2nd. To furnish suitable and efficiently designed reflectors to consumers on as liberal terms as possible.

3rd. To undertake illuminating engineering work on all lighting installations both old and new to the end of aiding consumers to secure the most efficient illuminations.

4th. To eliminate as far as possible all the worthless reflectors and replace them with efficient types, and to generally improve conditions of lighting service in every way possible.

Since the introduction of the Welsbach lamps there has been quite an overhauling of lamps, fixtures and shades for gas lamps to the great improvement of gas lighting service, and large amounts of money have been spent by consumers for the new devices.

ORGANIZATION AND CONDUCT OF A NEW BUSINESS DEPARTMENT SUITABLE FOR CENTRAL STATIONS IN CITIES OF 50,000 POPULATION AND UNDER

By W. Randolph Sweany.

The foundation of a New Business Department, like everything else, depends upon its setting; the public expects to have its patronage appreciated, therefore it is necessary to be in a position to handle in a business-like manner any request coming from the consumer. Complaints should receive the same polite attention as orders for service. The greatest advertisement is a satisfied consumer. Except in rare cases the operating man of the Central Station Company is not qualified to treat with the consumer. In some instances they feel antagonistic, owing to frequent reflections on the quality of service furnished. For companies of the size this paper concerns, it is not always found practicable for the head of the New Business Department, generally known as the Contract Agent, to devote his time to the office, in which case for the convenience of the consumer and the public, an office presided over by one with a thorough knowledge of the business, together with keen commercial instincts, should be established for handling orders, complaints, etc. It is not advisable to associate the title Complaint Department with this office, as it is too suggestively inviting. As the business grows this office should be brought under the control of the person in charge of the New Business Department, as it is necessary that this officer should be thoroughly in touch with the established business in order to intelligently prosecute a successful business-getting campaign.

The sale of electricity should be conducted along the same lines as any other staple, manufactured product, the number of solicitors employed in the New Business Department, theoretically, should be governed by the greatest number that can individually earn a profit on themselves, this can be readily figured out.

Below is set forth a diagram showing a practical organization, with lines of connection and intercommunication.

The organization, as shown on the diagram, is composed of eight men, all of whom are productive. The Contract Agent is responsible for the growth of the business; he is assisted by seven others, one General Office and Publicity Man, two Special, and four District Solicitors.

In cities with a population of 40,000, drop out two District Solicitors from the number shown in the above diagram. Where the population is 30,000, drop out two District Solicitors and Contract Agent, the Manager or Superintendent assuming the Contract Agent's duties. With a population of 20,000, drop out the District Solicitors, Contract Agent, and combine the duties of the Power and New Building Agent with that of the Sign and Heating, etc., Agent. For cities with a population less than 20,000, the Manager or Superintendent can assume the duties of the Contract Agent and Office Man, and the Soliciting Force be composed of Special Power and Sign, etc., Agent, and two District Solicitors. If found necessary to further reduce the force owing to limited territory, one or both District Solicitors can be dropped, retaining Special Power, etc., Agent.

The possibilities of a Central Station

Company's business are too great to neglect by curtailing in the Soliciting Department.

The qualifications of a successful Contract Agent are too numerous. He should have a technical and practical knowledge of electricity and mechanics in general, disciplinary ability, and extraordinary business capacity, combined with a strong personality, he must be able to inspire confidence, not only in the prospective consumer, but in the men under him; it is through this latter channel that he will obtain the best results. His duty is to keep himself and the Solicitors abreast of the latest developments in the application of electricity. The entire Contract Department should assemble at least two evenings a month, to bring out talking points, review business secured and talk over new plans; interest must not be allowed to lag. He should, as far as possible, become acquainted with the company's consumers, keep in touch with all civic organizations, new developments and improvements. In addition to supervising the work of the Solicitors and Publicity Department he should personally handle all the large contracts of what might be termed the wholesale end of business.

The position of Office Man, in charge of orders and advertising, should be filled by one conversant with the requirements of a general mercantile business; he should have at least an elementary knowledge of electricity and should be posted on the class of service furnished and the location of the company's lines. On him will fall the clerical work of the department, keeping records, compiling data, issuance of orders ,and last but not least the Publicity or Advertising work.

The Power and New Building Agent shown in the diagram should be selected with great care and of the highest grade obtainable. His qualifications are set forth in the following diagram:

Qualifications of Special Power and New Building Agent.	Technical Training. Practical Shop Experience. Ability to Estimate Cost of Operation under all Conditions. Ability to draw up General Specifications. Settled Age. Good Judgment. Salesmanship. Good Character. Attention to Detail. Persistence.

The duty of this special agent is combatting isolated plants and handling all power propositions on installations of five horse-power and over, also close acquaintance with architects and builders, draughting of specifications on wiring, installing of light, power and heat, in general, soliciting all power business, together with contingent lighting, this Agent starts with the building permit.

Should the city in question be a manufacturing center, a District Solicitor should be dropped and an extra Special Power, etc., Agent employed.

The Sign and Heating, etc., Agent shown in the diagram should have all the qualifications of a good salesman, no technical knowledge is necessary, yet he should understand the elements of electricity, appreciate the advantages of advertising, and be able to exploit same; his best education is experience, and if he is of the right sort his value grows with it. He should understand and be able to make mechanical drawings and have ability in free-hand sketching. The plain electric sign letter is not suitable in all cases, the majority of merchants prefer original and individual design in their signs. In addition to his duties as Sign Agent he should introduce small, motor-driven, exhaust fans, coffee mills, meat choppers, etc., also electric irons, coffee percolators, urns, griddles, etc.

The four District Solicitors should have all the qualifications of the Sign Agent and in addition possess a practical knowledge of illumination, the lack of this knowledge will retard the sale of electric lights and generate the dissatisfied customer quicker than anything else. Each of these solicitors should be placed in fixed territory and should be selected so that they are suited to the class of people they come in contact with.

IN GENERAL.

A space in the general office and the show windows should be devoted to display, demonstrating the different applications of lighting, small motors, and heating and cooking appliances; this will greatly assist in making popular devices that improve the day load. The Central Station to enjoy the business that belongs to it should advertise; this is frequently done ineffectually and much money wasted. At a moderate expense a very effective productive publicity can be maintained, a follow-up system of letters, interspersed with attractive folders with cuts and descriptions, will reach people not seen by the Solicitors; such things are bound to create a desire; when this is accomplished the consummation of the trade is left to the Solicitors. These letters and folders can be bought from advertising concerns engaged in this line of business at less cost than if designed by the Central Station Company and turned out by local engravers and printers, such of these that go to consumers can be enclosed with the monthly bill, saving postage. It is best not to be too general in advertising, drive one thing at a time. The consumer using electricity for lighting only presents a good opportunity for the Advertising Department; signs, small motors, heating and cooking devices, can be constantly brought to his attention, their application and usefulness shown.

In connection with the display part of the business, the Central Station Company should be able to demonstrate the uses of

Duplicate.
CONTRACT DEPARTMENT.
THE ....ELECTRIC CO.
CALL REPORT NO......................
Date .... 19....
Address ....
Saw M....................................Heard of from.............Seen at..........
Previous appointment......................Business ....
Present installation..
Called in reference to...
....
....
....................................Date of next appointment.................
....
Disposition ....
Complaints ....Collections ....
Expense incurred ....Checked by ....
Agent ....

each device it exploits. Although the sign business presents many difficulties, a business arrangement with one or a number of electric sign manufacturers is preferable. It pays to sell signs, heating and cooking appliances, sewing machine motors, etc., from samples shown in the display room.

Only by sticking to system can the best results be obtained. A great many Solicitors are prone to hit only the high places. Make a directory for the office, see that all are approached; not once, but many times. Keep a card file of calls and results.

For the convenience of Solicitors, loose leaf books that can be carried in the pocket should be provided. These books should contain rules, formulas and data on all subjects pertaining to their business, such as the average consumption of lamps, motors, etc. Percentage of average load to connected load in different businesses; cost of all current consuming devices; cuts showing the proper distribution of light, etc.

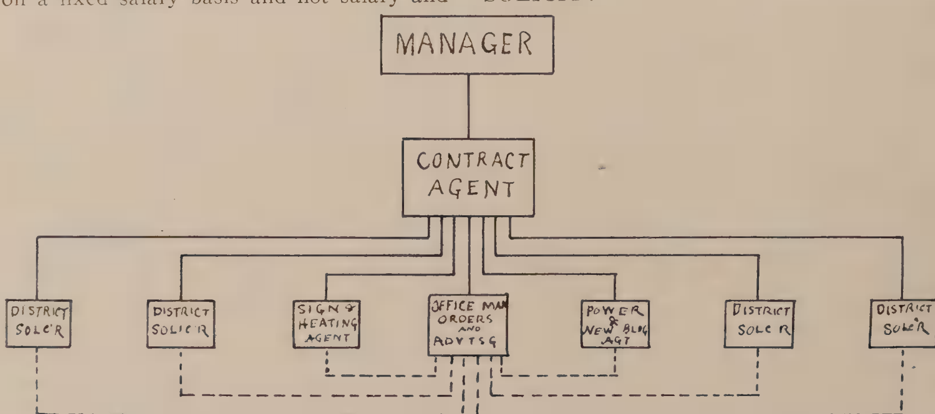
Regarding the necessary forms in the New Business Department, a check on the Solicitors, their calls and appointments, is best kept by the card file system. For the Solicitor, a calendar is used for appointments. The following form for calls and results from which is taken a monthly or bi-monthly summary, showing business secured, business lost, its cause and prospective business.

The remuneration of Solicitors should be on a fixed salary basis and not salary and commission. The right sort needs no extra incentive; if he is entitled to an increase and the business justifies it, give it to him, if not, drop him if he is dissatisfied; either the company or the Solicitor gets the worst of it on a commission basis.

RATES.

It is not meant in this paper to refer to rates other than to say they are, of course, the largest factor concerned in regulating the amount of new business secured. They should be as simple as possible, published, not concealed, and with the exception for signs and show lighting, which can be placed on a switching circuit under control of the company, should be entirely on a meter basis.

Electricity is a mysterious force and as the steady going public dislikes unknown quantities, a campaign of education is necessary, which, if properly and systemmatically carried out, will surely bring the desired results. The public is simply waiting to be taught the advantages the use of electricity offers. With it can be supplied light, power and heat, in innumerable ways; this the general public understands only in a vague manner. At least one of the three commodities is indispensable to every human being—the desire being created owing to the necessity, the advantages can be readily shown. Believe in it yourself and you will inspire confidence; present it properly and business must follow. ADVERTISE! SOLICIT!



Miscellaneous News

ALAMEDA, KAN.—The report of Superintendent Kahn, of the municipal electric light plant, shows an increase in the earnings of the plant for the last year of $10,250.45. The earnings for the year previous amounted to a fraction over $64,000.

CLAY CENTER, KAN.—It looks as though Clay Center will not be able to build its municipal electrical light plant at once, for which bonds have twice been voted. The city council expected to let the contract for the building and plant but a temporary restraining order has been secured by the private company now doing business here and the matter is again tied up. The restraining order is secured in the name of the State, ex rel. C. C. Coleman, Attorney General. The city authorities say they expect to fight it through, and if this is lost another election will be called. There seems to be no difficulty in getting the city to vote the bonds.

KANSAS CITY, MO. — Should the council refuse to modify the Fleming-Wilson ordinance so that it will be accepted by the grantees, Mayor Beardsley may urge that the city take possession of the plant of the Kansas City (Missouri) Gas Company.

"I am not wedded to municipal ownership," said the mayor, "but the Kansas City (Missouri) Gas Company would force the city to it, or to get gas through another company. It will be best for the city to have one company with a monopoly, but that company must be subject to regulation by the city in the matter of rates and other terms, either by specific language in the franchise or by the right to purchase unqualified. In the terms offered by the old company no such power of regulation is reserved to the city."

KINGSTON, N. Y.—There is believed to be little if any likelihood that the work of the committee appointed by the mayor to investigate the local electric power situation will result in the establishment of a municipally-owned and operated street lighting system for some time to come.

Even those who advocate the municipal ownership idea are now coming to see that it would be unwise to carry out that idea just now and a contract with a private company will doubtless be awarded for the next three years by the common council. It is becoming generally feared that if a municipal lighting plant were established it would interfere with the carrying out of the water supply scheme.

LOCKPORT, N. Y.—The three citizens who will serve on the special committee to be known as the municipal electric lighting plant committee were appointed. They are Mr. D. Elwood Jeffery, former alderman from the Third Ward; Hon. David A. Milla, and Mr. Henry Murphy. These men will serve with Mayor Howard M. Witbeck, Mr. James J. Moran, chairman of the committee on lamps and gas; Mr. J. Frank Smith, city attorney, and Mr. Julius F. Frehsee, city engineer and surveyor.

The committee was appointed for the purpose of considering the advisability of erecting and constructing a municipal lighting plant and report to the common council at the regular meeting the third Monday in November.

MOBERLY, MO.—The Moberly Electric Light Company will, we are reliably informed, in a very short time expend about fifty thousand dollars on the present electric light plant and practically make the plant entirely new. When completed they will furnish day power and give first-class service in every way.

NEW YORK (Borough of Brooklyn).—The work of changing the 3,000 and more open flame gas lamps of 20 candle-power each in Richmond Hill and the town of Newtown to mantle gas lamps of three times the illuminating efficiency, or 60 candle-power each, is to be begun the last week in September and it will be completed in sixty working days. The lanterns are to be of the best pattern known to-day, a marked improvement over the old style. A total of 105 new arc lights of 1,200 candle-power have been installed in the borough since last January, and this is far more than all the new arc lights placed before that in the eight years since consolidation. This has been rendered possible by the reduction made in the cost of the service by the light companies, and as a result there is no increase in the total cost to the city over previous years.

With the alteration of the open flame gas lamps to mantle lamps the total lighting of the borough will be increased fully 50 per cent. over last year.

NEW YORK (Borough of Richmond).—Acting Mayor McGowan is not inclined to agree with Comptroller Metz that the only means of giving a proper lighting service to Staten Island is the establishment of a municipal lighting plant. Mr. McGowan bases his opinion on a report made to him by Chief Engineer Lacombe, of the Department of Water Supply, Gas and Electricity. Mr. Lacombe reported that the situation in Staten Island was not nearly so bad as has been indicated in the complaints from that borough, and he added that if a little time was given to the company to improve its plant it would be able to provide an adequate service.

The company has been handicapped because of its failure to borrow money for the extension of its plant and because of the great demands made upon it for the lighting of the Staten Island beaches. But with the close of the summer season the company, Mr. Lacombe said, will be able to supply better public lighting for the streets, and before next summer will undoubtedly be in a position to meet all the demands.

Mr. McGowan and Mr. Metz had a talk on the matter. The Comptroller stuck to the municipal lighting plant, but if he insists on bringing his proposal before the Board of Estimate it will undoubtedly be opposed by Mr. McGowan.

ORANGE, N. J.—By a unanimous vote the Orange Common Council have decided to proceed with the erection of a municipal electric lighting plant. The plant is to be built in conjunction with the water pumping plant under a law passed by the Legislature last winter, in which there is no referendum. This fact was evidently overlooked by the legislators, who were so careful to put a referendum in all the other municipal lighting plant bills which were before the Legislature.

James M. Seymour, Jr., was engaged as consulting engineer and authorized to prepare plans and specifications.

At present Orange pays $85 an arc light of 2,000 candle-power, which, Mr. Seymour declares, is in reality less than 1,300 candle-power. According to his estimates the cost under municipal operation will be less than $50 a year. Mr. Seymour is to run the plant for the city for six months after it is installed. The plant will be used also for pumping for the water and sewer departments.

POUGHKEEPSIE, N. Y.—Officers of the Poughkeepsie Light, Heat and Power Company say that when the improvements now under way at the power station are completed Poughkeepsie will have one of the largest and most efficient power plants to be found in any of the smaller cities in the country. Within the past year there has been a new system of street lights inaugurated here. It is known as the "luminous arc light," and is claimed to give a much steadier and more diffused light than any other yet invented.

ROCHESTER, N. Y.—Bids were opened for lighting the streets of the city with electricity. While there was but one bidder, the Rochester Railway and Light Company, present holder of the contract, its offer for municipal lighting is quite satisfactory to Rochester. Its bid was as follows:

Single arc lamps fed by overhead wires, $57.95 per light per year, former price $78.50 per year; single arc lamps fed by underground cable, $68 per light per year, former price $78.50; double lamps on iron poles, fed by underground cable, $62.96, former price $60.61; incandescent lamps, $19.34 per lamp per year.

ST. LOUIS, MO.—The question of municipal lighting was brought to the attention of the board of public improvements through the submission by Joseph P. Whyte, harbor and wharf commissioner, of an ordinance providing for letting the lighting contract for an additional twenty years from September 1, 1910. This is the time when the present contract held by the city expires. He suggests that if the electric lighting proposals are not better than in Detroit, which owns its own lighting plant, the city should make provisions for a municipal plant. Several years ago the city authorized the setting aside of $140,000 each year to erect a municipal plant in time to furnish the city with lights by September 1, 1910, but no money has been set apart in accordance with this ordinance.

SYRACUSE, N. Y.—The much-looked for decision of the State Commission on Gas and Electricity on the complaint of the city of Syracuse, regarding the prices charged for gas and electricity in that city, which will have considerable bearing on the complaint of the citizens of Albany, was made public and the conclusions of the commission are: Prices to be charged for gas after October 1, 1906, 95 cents per thousand feet. Price to be charged for electricity to private consumers from October 1, 1906, to October 1, 1907, 9 cents a kilowatt hour; after October 1, 1907, 8 cents per kilowatt hour. Price to be charged for street lighting after October 1, 1906, $68 per arc lamp per year. Heretofore Syracuse has paid $85.77½ per arc light in her streets; $1.00 per thousand cubic feet for gas, and 12 cents per kilowatt hour, with a 2 per cent. discount for cash payment for electricity delivered to private consumers.

WATERTOWN, N. Y.—J. O. Mange, general manager of the Watertown Electric Light Co., is superintending extensive improvements that are being made by his concern. The new generators, with the water power that the company is now buying, and other new facilities, will double the capacity of the plant.

The company has so far installed 125 of the 230 new luminous arc lights which will replace the old lights that have hung since the concern was organized. These arcs are the latest of their kind, manufactured by the General Electric Co., of Schenectady. They burn with an intense white light and are said to be far superior to the old ones.

The Illuminating Engineer

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The Calculation of Illumination

By Van Rensselaer Lansingh.

It is well recognized to-day that in any careful work which the illuminating engineer is called upon to do, it is necessary to calculate from the photometric curves of the source of light to be used, the illumination which will be obtained at different points. It is possible to-day to obtain reliable polar or photometric curves of a large number of sources of light but the calculation of the illumination from the same is more or less of a laborious task. Sometimes it is desired to obtain simply the normal illumination, but in general it is necessary to obtain the horizontal illumination if it is desired to find the resultant illumination due to the light from several different sources. Such calculations ordinarily involve the cube of the cosine of the angle between the perpendicular and the rays in question and unless proper tables are available, involve considerable labor.

In order to minimize this, a new paper has been prepared, a copy of which is herewith shown. In the upper left hand corner is space for the polar curve of any given source of light, which, as it is usually symmetrical, is only carried to one side of the vertical. If, however, the light should hang at an angle so that the polar curve were not symmetrical with respect to the vertical, it would be necessary to plot the curve to the left of the vertical. This, however, is not generally the case. Owing to the fact that in a large majority of cases there are apt to be more or less sudden fluctuations in candle-power near the nadir, the rulings are provided so as to easily care for readings at 10 degrees instead of 15 degree intervals. The distance of the source of light above the plane illuminated is divided, as will be noted, into twelve equal divisions, so that this height is adapted for two, three, four, six or twelve feet above the plane illluminated. The distances from the foot of the perpendicular below the light are divided accordingly. Thus, if the light were twelve feet above the plane illuminated, the calculations could be carried out for a distance of 40 feet from the perpendicular. In the table at the right hand side will be found a table of Cos.^{3} Φ, where Φ is the angle between the perpendicular and any given ray, which is applicable for those cases where a new diagram must be drawn, such as for example, for a height of 5 feet above the plane illuminated.

Two tables are also prepared, one for the normal illumination I_N and another for the horizontal illumination I_H. The following notation is used: d is the distance from the source

of light to the point illuminated. CP is the candle-power. D is the distance from the foot of the perpendicular to the point illuminated. h is the height of the source of light above the plane illuminated. With the formula given, viz. $I_N = \frac{CP}{d^2}$ for the normal illumination and $I_H = \frac{CP}{h^2} \cos^3 \Phi$ for the horizontal illumination, it is a simple matter, after having laid out the polar or photometric illumination curves by the aid of a slide rule. If there are two sources of light, the resultant illumination can be easily plotted. It is thus possible to calculate and plot both of these curves in ten or fifteen minutes, whereas, the labor involved would be very much greater.

The ordinary polar or photometric curve is often deceptive even to the experienced illuminating engineer. With some of the modern types of reflectors, a large amount of light is thrown directly downward and when compared with the curve of a bare lamp or with the curve of a globe or reflector which throws the maximum light sideways, it looks as if there were a larger increase in the illumination in different zones than is actually the case. This is often deceptive and in order to find out how much light there is in any given zone, it is necessary to take advantage of the Rousseau Diagram. In the Rousseau Diagram the candle-power readings of the photometric or polar curve are laid off directly to any convenient scale and the mean height of any zone gives the mean zonal candle-power. Thus, the area between any two lines, say between 70 and 90° as shown on the diagram, the curve and the base line divided by the length of the base line would give the mean height or total amount of illumination in the zone in question. In case it is desired to obtain the mean lower hemispherical candle-power, it would be necessary to take the area between zero and 90° and divide it by the length of the base line. In order to measure these areas, it is customary to use a planometer, but as such an instrument is not ordinarily available, the Rousseau Diagram has been cut up into twenty equal parts shown by the red lines on the paper. Ten of these are above the horizontal or 90 degree line and ten below. If, now, we measure the height of the curve from the base half way between any two red lines, we will obtain the mean height as, generally speaking, the curve can be considered a straight line between any two such divisions. By this method we can obtain the mean height of any zone or hemispherical candle-power without being compelled to calculate the areas. In the case of the mean hemispherical candle-power all we have to do is to add the 10 ordinates and point off one decimal point. It thus becomes a simple matter with a hundredths scale, which is ordinarily used in measuring such heights, to obtain at once without any other instrument, the total amount of light in any given zone or the mean lower hemispherical or mean spherical candle-power, the two values most frequently desired.

These sheets which are gotten up in a convenient form measure about 18″ long and 12″ wide, and can be obtained from the Engineering Department of the Holophane Glass Company, which has published this new paper. It should decrease this part of the work of the illuminating engineer at least one-half.

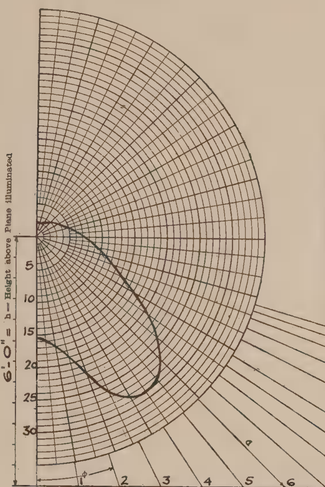
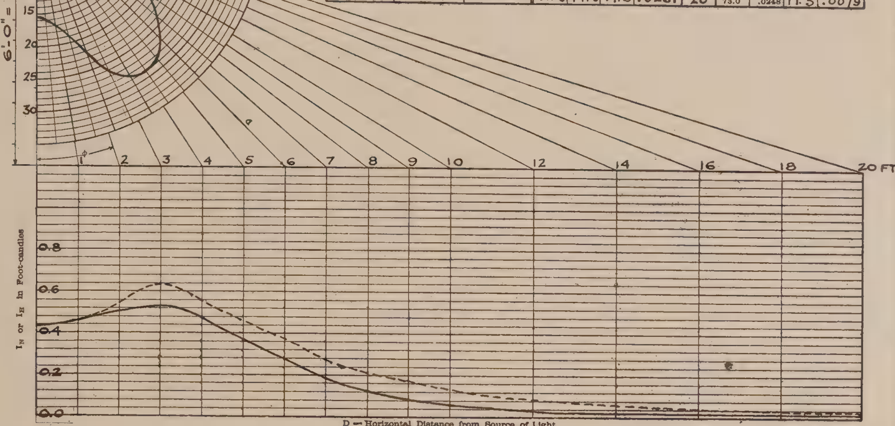


Table of Cos $^3\phi$

$\phi°$	Cos $^3\phi$	$\phi°$	Cos $^3\phi$	$\phi°$	Cos $^3\phi$
1	1.000	29	.668	57	.161
2	.998	30	.649	58	.149
3	.998	31	.630	59	.137
4	.993	32	.610	60	.125
5	.988	33	.590	61	.114
6	.983	34	.570	62	.103
7	.978	35	.550	63	.0936
8	.971	36	.529	64	.0842
9	.963	37	.509	65	.0754
10	.955	38	.489	66	.0671
11	.945	39	.469	67	.0596
12	.935	40	.449	68	.0526
13	.925	41	.429	69	.0460
14	.913	42	.410	70	.0400
15	.901	43	.391	71	.0345
16	.888	44	.372	72	.0295
17	.874	45	.353	73	.0248
18	.860	46	.335	74	.0210
19	.845	47	.317	75	.0174
20	.829	48	.300	76	.0142
21	.813	49	.282	77	.0114
22	.797	50	.265	78	.0089
23	.780	51	.249	79	.0069
24	.762	52	.233	80	.00525
25	.744	53	.218	81	.00384
26	.726	54	.203	82	.00270
27	.707	55	.189	83	.00182
28	.688	56	.175	84	.00114

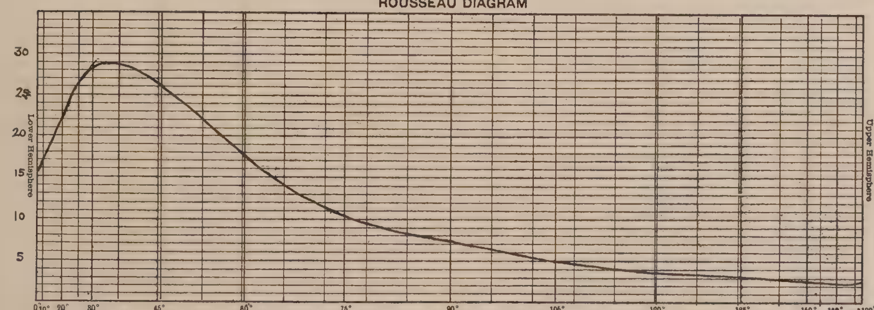
$I_N = \frac{C.P.}{d^2}$ $\qquad$ $I_H = \frac{C.P.}{h^2} \cos^3\phi$

d	d^2	C.P.	I_N	D	ϕ	Cos $^3\phi$	C.P.	I_H
6.0	36.0	15.5	0.430	0	0	1.000	15.5	0.430
6.1	37.2	17.0	.457	1	9.0	.963	17.0	.454
6.3	39.6	21.5	.543	2	18.0	.860	21.5	.504
6.7	44.8	27.0	.603	3	26.5	.716	27.0	.537
7.2	51.8	29.0	.559	4	33.5	.580	29.0	.467
7.9	62.4	29.0	.465	5	39.5	.459	29.0	.370
8.5	72.2	27.0	.374	6	44.5	.362	29.0	.271
9.3	86.4	24.0	.278	7	49.5	.273	24.0	.182
10.1	102.0	22.0	.215	8	53.0	.218	22.0	.133
10.9	118.8	20.5	.175	9	56.0	.175	20.5	.0997
11.7	136.8	18.5	.135	10	59.0	.137	18.5	.0705
13.5	182.2	15.5	.0852	12	63.5	.0889	15.5	.0383
15.3	234.0	14.0	.0598	14	66.5	.0633	14.0	.0246
17.2	295.8	13.0	.0439	16	69.0	.0460	13.0	.0166
19.1	364.8	12.0	.0329	18	71.5	.0320	12.0	.0106
21.0	441.0	11.5	.0261	20	73.0	.0248	11.5	.0079



ILLUMINATION CURVES

ROUSSEAU DIAGRAM



M.L.H.C.P. — 17.64 Ratio — $ M.S.C.P. — 10.61 Ratio $ M.U.H.C.P. — 3.58 Ratio $

M.L.H.C.P. — M.S.C.P. — M.U.H.C.P. —

Source of Light 16 C.P. LAMP

Remarks

Glassware HOLOPHANE REFLECTOR No. 7380

Other Equipment NONE

Photometric Curve from E.T.L.'s Plate No. 735

Illumination Curve No. Sp.

Rousseau Curve No. Sp.

Plotted by H.M.L.

Checked by A.J.M.

Date OCT. 17-1906.

SHEET NO. Sp.

ENGINEERING DEPARTMENT
HOLOPHANE GLASS CO.
NEW YORK.

TABLES AND CURVES OF ILLUMINATION.

Plain Talks on Illuminating Engineering

III. MEASUREMENTS OF LIGHT AND ILLUMINATION

By E. L. Elliott.

Engineering is applied science, and the foundation of all science is measurement. In order to handle illumination as a branch of engineering, therefore, it is necessary to understand the ways and means used for measuring light and its several fundamental effects. The nature of the measurements in use at the present time is unfortunately such that they are often misunderstood and misconstrued; hence the special necessity of giving the subject careful attention.

In the first place let it be clearly understood that light and illumination are two different things, and, therefore, require different units of measurement. Light is the *cause*, illumination the *effect*. If this simple distinction is kept in mind it will generally serve to prevent a misunderstanding of terms.

As we stated in the first part of this discussion, light has one measurable property, namely: intensity (strength, brilliancy, brightness). All other measurements and units are derived from this one property.

The different derived quantities applying to Light are,

First: The total quantity of flux of rays ("mean spherical candlepower").

Second: The brilliancy of the luminous surface of light sources ("intrinsic brilliancy").

Third: The relative quantities of the different color rays.

The measurements of Illumination derived from the fundamental measurement are:

First: Intensity of illumination on a given surface.

Second: Brightness of the image on the retina of the eye.

It has been previously stated that the intensity of light varies with the direction of the rays from the source. It follows, therefore, that the fundamental quantity known as "intensity" can be measured in only one direction at a time.

Measurement is the comparison of one quantity with another of the same kind which is invariable, or as nearly so as conditions will permit. The invariable quantity is called the *unit*, or *standard*. The measurement of light, therefore, necessitates an invariable unit as a standard; that is, a light which shall have always the same intensity in a certain specified direction. It is practically impossible to secure an absolutely invariable unit of any kind; and to obtain a light-source which can be easily reproduced, and which will always give the same intensity within the limits of variation common with other measurements, has proven a very difficult problem, which has not yet been satisfactorily solved.

The necessity of measuring light first arose with the introduction of illuminating gas, and as candles were then the ordinary sources of light, it was very natural to refer the light-power of the new luminant to that of the candle; hence the term, "candle-power." As crude a light source as the candle may seem to be, it was found, nevertheless, that, with proper precautions, candles could be made which would, under stated conditions, give a fairly uniform intensity in a direction at right angles to the flame; and the standard candle is still used as an actual standard light-source, although a lamp burning a chemical fluid is used where a greater accuracy is desired.

When the candle-power of a light source is given the quantity usually meant is the intensity of the rays of that light in a horizontal direction, unless some other direction is speci-

fied. This is the only meaning that should ever be given to the term, but it is often used loosely when other quantities are meant.

The measurement of the candle-power, or intensity, of a light source is made by comparing the illumination which it can produce upon a given surface with the illumination produced upon an equal surface by the standard light. The eye, like the other senses, can judge very accurately of equalities; that is, it can determine when two surfaces are equally illuminated, and the method of operation of all practical photometers consists in adjusting the distances of the two lights so that the illumination produced on the given surfaces is equal. The relative intensities are then determined by the law of inverse squares. Thus, if the surfaces are equally illuminated when the standard light is one foot away and the light being measured two feet, the intensity of the measured light is four times that of the standard light.

The great variety in the construction of photometers is mainly due to different arrangements for viewing simultaneously two similar surfaces illuminated respectively by the two light-sources. It is not within the scope of our subject to examine these various devices. All the more common forms are treated of in an excellent little book by Prof. Stine, entitled Photometrical Measurements; and the whole subject exhaustively treated in Palaz's Industrial Photometry. It will perhaps be well, however, to describe a form of photometer which, on account of its simplicity of construction and accuracy of operation, has superseded all other varieties, except where the greatest accuracy is required; and even in many of these cases it is preferred. We will describe the general principles of its construction, from which the reader may, if he chooses, be able to construct an instrument of his own. As before stated, the essential part of a photometer is the device for comparing the two illuminated surfaces. The arrangement we are about to describe is the invention of Prof. Bunsen, who also invented the gas burner having holes at the bottom to admit air to mix with the gas before burning, and which is the basis of all incandescent gas burners at the present time.

The surfaces which are illuminated by the light under comparison are technically called the "screen"; and from its method of construction the screen of the Bunsen photometer is commonly called a "grease-spot screen" and the photometer the "grease-spot photometer." The following simple experiment will show the manner in which the screen acts: place a drop of oil or water in the center of a sheet of white paper. If you now hold the paper between your eyes and a light-source, you will see a bright spot in the center; the grease spot being translucent, transmits more light than the surrounding paper. Now hold the paper so as to see it by reflected light, that is, with the light source on the same side of the paper as your eye. The grease spot now appears darker than the surrounding paper for the reason that the light falling upon it, instead of being reflected to the eye, passes through. Lastly, place the paper between two light sources. If you look at one side the grease spot will be illuminated by the light on the *opposite* side of the paper passing through, while the surrounding paper will be illuminated by the light on the *same* side by reflection. By slowly moving the paper back and forth between the two light-sources, you will find a position where the grease spot will (almost) disappear. This shows that the illumination by the light on the one side, which is transmitted through the oiled surface, is equal to the illumination from the light-source on the other side, shown by reflection from the surrounding paper. Assuming that the proportion of light transmitted is equal to the proportion reflected, the light-powers of the two sources are then as the squares of their distances from the screen.

The photometer consists of a bar, or other support, of the necessary length, which depends upon the intensities of the light-sources to be measured, with a standard light-source at one end and a means of placing the light-source to be measured at the other. A box, or other support for the screen is then provided, and arranged to move along the bar between the two light-sources. In order to see both sides of the screen at the same time, two strips of mirror glass are placed at a slight inclination on either side, as shown in diagram in Fig. 1. By looking directly edgewise at the screen the two sides will be seen reflected in the two mirrors.

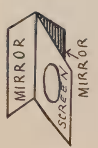


FIG. 1.—ARRANGEMENT OF SCREEN AND MIRRORS.

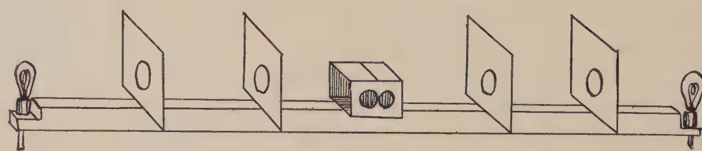


FIG. 2.—ARRANGEMENT OF PARTS ON BAR.

For ordinary work, such, for example, as the measuring of electrical lamps, a photometer bar five feet in length will be found sufficient. A convenient arrangement of the screen is to place it in a slide fitting into the middle of a box 4 inches square and 6 or 8 inches long, the box being arranged in any convenient way to slide along the bar. The box should be carefully blackened on the inside with a mixture of lamp black in rather thin shellac varnish. It is also important, of course, to prevent all light, except that from the two light-sources under comparison, from falling upon the screen. This may be done by either working in a room with blackened walls, which is usually difficult to obtain, or by enclosing the instrument with black curtains to shut out outside light. Care must be taken not to place any surface, even a black one, close behind either light-source, unless two surfaces exactly alike are placed at equal distances from both sources; for even the blackest of surfaces reflect a measurable amount of light and will unbalance the results. One of the best ways to prevent outside light from interfering, is to place along the bar a series of diaphragms, which may be pieces of ordinary card-board painted black, with openings cut in them the size of the light-sources. This arrangement is shown in Fig. 2. By using a sufficient number of such screens a photometer may be used in an ordinarily light room without giving incorrect results.

There are several methods of making the photometer screen, one of the simplest being the following: Secure some of the best possible quality of white linen ledger paper. Solder a penny to the end of a piece of stout wire for a handle. Heat the penny hot enough to readily melt the parafine. Give it a coating by holding it against a lump and then press it firmly against the white paper for a moment. As soon as the spot is set, reverse the paper and apply the penny, previously coated, to the opposite side of the paper, taking care that the two impressions shall exactly register. Surplus parafine may then be taken off by placing a clean blotter over the spot and laying a hot flat iron over it. A number of such screens may be prepared at the same time and kept where they will be free from dust for future use. Screens should be changed very frequently, as they become soiled in use and interfere with the accuracy of the results. Another good method is to double a piece of white paper, cut a hole through the two sheets, and place a piece of tracing paper between.

As a standard light-source, the one

most easily provided and which is capable of giving very good results, may be made from a common student lamp by using a metal chimney outside the glass chimney, having a slot in one side which will cut off the top of the flame as seen from the screen. The lamp should be allowed to burn until it becomes thoroughly heated before measurements are made, and it is also essential that the room in which the work is done be kept thoroughly ventilated. In many cases only comparative results are desired, and in these cases a light-source of the same kind as the one to be measured may be used as a standard. For example, an incandescent gas burner may be used, it being supplied from the same gas pipe as the light being measured. Even though the reader may not use a photometer for practical measurements, it would in many cases pay him to construct a simple experimental instrument for the sake of the knowledge that he will gain of the principles of light measurement. If he has not the time or facilities for this he should, at all events, obtain the privilege of using a photometer sufficiently to familiarize himself with the principles of its operation.

In determining the setting of the screen in the Bunsen photometer, two different methods are used disguished as the "comparison" method and the "disappearance" method. In the comparison method both sides of the screen are kept continually in view, and the setting made in the position at which the two sides have the same appearance. In this case the spot does not disappear on either side, but the balance consists in the similarity of the two sides. In the disappearance method, one side of the screen is observed, and the position found at which the spot most nearly disappears. The screen is again moved until the spot disappears on the opposite side; the mean between these two positions is taken as the final reading. In practice the spot can rarely be made to disappear entirely, owing to the difference in color of the two lights. Even when measuring two light-sources of the same kind, such as incandescent electric lamps, there is usually sufficient difference in color to be perceptible on the screen. With a little practice, however, a considerable difference in color will not interfere with the setting of the screen by either method. The comparison method is quicker and is more generally employed; but where light-sources of the same kind are being compared the disappearance method is probably the more accurate, especially for those not accustomed to using a photometer.

While the intensity of light in a given direction is a valuable measurement in itself, affording a means of comparing light-sources of the same kind, as for example, gas jets, mantle gas burners, etc., it does not by any means supply all the knowledge necessary in regard to the value of a light-source. Light sources distribute their rays unequally in different directions, and it is thefore important to know just how they distribute their rays, that is, to know the intensity of the light in different given directions. For this purpose it is necessary to provide a means of either turning the light-source itself, as may be done with an incandescent electric lamp, so that the rays in different directions may reach the photomenter screen; or, in case the light-source can only be used in one position, as with gas light and electric arc lamps, it is usual to use mirrors placed in different positions about the light-sources, and measure the rays which are reflected from the desired directions. The mechanical details for carrying out such measurements will be found described in the works already referred to.

The methods of recording the results are important, and since they are usually assumed to be understood by writers on the subject, we may give a little time to an explanation.

For many purposes the most satisfactory method of expressing the results is by means of diagram, which

is technically called a "curve." The method of drawing such a diagram may be best explained by means of a practical example. For this purpose we will take the common form of sixteen candle-power electric lamp. We will assume that the lamp has been measured on a photometer for the intensity of the light at directions or angles ten degrees apart above and below the horizontal and that the values obtained are as follows:

Angle.	Intensity.	Angle.	Intensity.
10° above	16	10° below	16
20° "	15½	20° "	15
30° "	14	30° "	14½
40° "	22½	40° "	13
40° "	12½	40° "	13
50° "	10	50° "	12
60° "	8½	60° "	10
70° "	2½	70° "	8
80° "	2	80° "	7½
90° "	0	90° "	7

We then draw horizontal and vertical lines, and from their intersection as a center draw intermediate lines ten degrees apart, as shown in Fig. 3. Use any convenient length as a unit to represent one candle-power; then lay off along each line a number of these units equal to the number of candle-power intensity in the direction represented by the line. It will save time to first lay off the unit distances along the horizontal line, and then draw circles through each of these points, thus dividing all the other lines nito the same equal units, as shown in Fig. 3. On the horizontal line the intensity is sixteen, and we lay off sixteen units, marking the point with an x. At 10 degrees below the intensity is 15½, and we lay off a distance from the center of 15½ units. At 20 degrees below the intensity is 14, and we lay off 14 units; and so on for each of the other figures. We now draw a curved line which shall pass through these different points as shown in Fig. 3. This curve, by the distance of the different points on it from the center, shows the relative intensity of the light at the angle corresponding to that point.

The advantage of this kind is that it appeals directly to the eye, and gives an idea of the intensity at every point at once, whereas a table of figures at best can only suggest to the

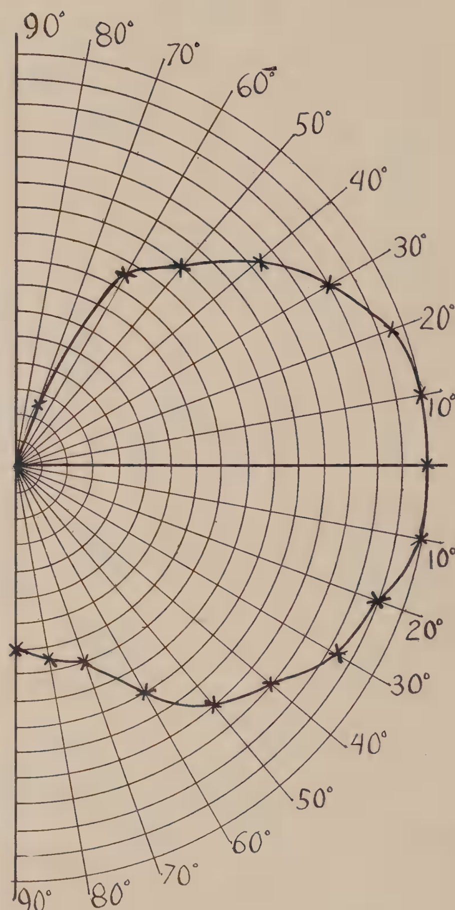


FIG. 3.—METHOD OF PLOTTING DISTRIBUTION CURVES.

mind a comparison between two values. Such a curve as we have drawn in this case is the curve distribution in the verticle plane.

In the case of many light-sources, such as incandescent electric lamps, and flames, the intensity in the horizontal plane also varies, and may be represented by a curve in the same manner. In order that the curve of vertical distribution may be of value it is neccessary that it represent the

average value around the vertical axis at the angle in which it is taken. In the case of incandescent electric lamps this is generally accomplished by revolving the lamp around its vertical axis while the measurements are being made.

The curve of vertical distribution is very useful for two purposes, viz.: to show just what the strength of light is at any particular angle from the vertical, and to furnish a means of determining the whole quantity of light emitted. In using this curve, however, it must be carefully remembered that it represents nothing more than what is claimed for it; that is, the intensities at the different angles. There is a tendency involuntarily to assume that the size of the curve, or rather the surface which it encloses, is an indication of the quanity of the light given out, which, of course, is an absolute error. The curve showing the total quantity is of an extremely different character, as we shall see later.

The term usually to signify the total flux, or quantity of the light emitted, is "mean spherical candle-power,"—a term which is exceedingly clumsy to use on account of its length, and probably more often misunderstood than otherwise. For example, it is quite natural to infer that mean spherical candle-power, or intensity, would be correctly expressed by finding the mean, or average, of the intensities in all the different directions of the curve of vertical distribution, and this meaning has even been given by technical writers. When compared with the actual meaning, however it will be seen to be a very wide error.

In order to understand the subject of total flux or spherical candle-power, we must first get a clear idea of *quantity* of light as distinguished from mere intensity. A light-source may be given an exceedingly high intensity with a very small spherical candle-power, or total flux; as, for example, an electric spark. Or, to illustrate by another class of measurements which are anologous, intensity of light correspond to temperatures of heat. It is possible to have an exceedingly high temperature with a very small quantity of heat. A single drop of molten platinum is vastly hotter; that is, of higher temperature, than a ton of molten iron, but it is evident that the quantity of heat in a ton of molten iron is vastly greater than that in a drop of molten platinum. Quantity of heat is determined by the amount of material which can be raised to a certain temperature, and similarly, quantity of light is measured by the amount of surface which it can illuminate up to a certain degree of intensity, or brightness.

In order to understand the measurement of light as to quantity, therefore, it is necessary to study the measurement of illumination; and this brings us back again to the standard light-source. Taking the candle as such a source, and considering the horizontal rays only, the intensity of the illumination which it can produce will depend upon the distance of the surface from the flame. At one foot distance a surface in vertical position, that is, perpendicular to the rays, will have a certain brilliancy, or intensity. At two feet distance the surface will have, according to the law of inverse squares, one-quarter the intensity; at three feet one-ninth of the intensity, and so on. To obtain a unit of intensity, therefore, it is necessary to use a unit of distance in connection with the standard light-source. When the English system of measurement is used one foot is taken for the unit distance; that is, the illumination produced on a surface one foot from the candle is taken as the unit, and is called a "foot-candle." An illumination of two foot-candles is then the illumination produced upon a surface by *two candles* at a distance of one foot

The Electrolytic and Metallic Arc

BY ISADOR LADOFF.

(*Concluded.*)

The *light emission* is not intimately connected with the electric conductivity, but is a *function of the temperature of the arc.*

The supply of ions coming from the cathode. One must assume that the ionization process to be staple requires at each voltage a certain amount of current, and dies out when the current is lowered below a certain limit. There is strong evidence in favor of the assumption that *the cathode is the electrode at which the primary generation of ions takes place.*

As the melting point of the metals plays such an important part in the arc, we have given them in the accompanying table.

Grove claimed in 1846 that various metals produce arcs of different luminosity. He arranged the metals accordingly in series, in which each foregoing metal is claimed to produce a more brilliant arc than the next following metal, namely: K, Na, Zn, Hg, Fe, Sn, Cu, Ag, Au, Pn. With the exception of Ag and Au, the metals are arranged in the order of increasing melting points. However, we do not know whether Grove was aware of the fact or not.

As the luminosity of the arc is intimately connected with the spectrum of the arcing material, we will say a few words concerning spectroscopy.

Sir Norman Luckier's hypothesis of inorganic evolution (London, 1900), is based on the fact, that the spectra of bodies are functions of the temperature at which they are observed. Four distinct temperature stages are indicated by the varying spectra of the metals, which, taking iron as an example, are:

I. The flame spectrum, consisting of a few lines only.

II. The arc spectrum, differing from the spark spectrum in the enhancement of some of the short lines and the reduced relative brightness of others.

III. The arc spectrum consisting of two thousand lines or more.

IV. A spectrum consisting of a relatively very small number of lines which are intensified in the spark.

At the temperature next lowest to that of the very hottest stars, we find metals in the state in which they are observed when the most powerful jar spark is employed. At a lower temperature still the metals exist in the state produced by the electric arc. The similar changes in the spectra of certain elements, changes observed in the laboratory, sun and stars are simply and sufficiently explained on the hypothesis of dissociation. The verdict of the stars is, that, as in all previous human experience, a higher temperature brings about simplification; this is also the verdict of the ionic or corpuscular theory of matter.

According to I. I. Thompson, the constituent to which the conductivity of the gas is due, consists of charged particles, the conductivity arising from the motion of these particles in the electric field (I. I. Thompson, *Electricity and Matter*). The mass of a carrier of a negative charge must be only about one thousandth part of the

TABLE OF MELTING POINTS OF THE METALS.

	Melting Point.	Spec. Gr.	Atomic Vol.	Atomic Wt.	Elect. Conduct.	Latent Heat of Melting.	Heat of Oxidation.	Latent Heat of Vapori-zation.
Carbon	2500	2.1	6	12	....	....	......	......
Titanium	2500	5.1	9.4	48	....	....	......	......
Osmium	2500	22.5	8.6	22.5	....	....	......	......
Vanadium	2000	5.5	9.2	51	....	....	......	......
Chromium	2000	5.5	8.0	52	....	....	......	......
Ruthenium	2000	12.2	8.4	103	....	....	......	......
Iridium	2000	22.4	8.6	193	....	....	......	......
Rhodium	1900	12.1	8.6	104	....	....	......	......
Platinum	1775	21.5	9.2	196	$9.33.10^4$	27.18 cal.	......	......
Manganese	1500	7.5	7.3	55	....	....	......	......
Zirconium	1500	4.1	22	90	....	....	......	......
Palladium	1500	11.4	8.3	106	....	....	......	......
Tungsten	1500	19.1	9.6	184	....	....	......	......
Iron	1400	7.8	7.2	56	$8.36.10^4$	33 cal.	1352.6	......
Cobalt	1400	8.6	6.8	58.5	....	....	......	......
Nickel	1300	8.7	6.8	59	$8.50.10^4$	....	......	......
Boron	1300	2.5	4.4	11	....	....	......	......
Silicon	1200	2.3	12	28	....	....	......	......
Copper	1054	8.8	7.2	63	60.3 to 61.7		......	......
Gold	1045	19.3	10	198	47.07 to 42.12		......	......
Silver	950	10.5	10	108	60.39 to 65.64		27.07 cal.	27.31
Beryllium	900	1.64	12	9	....	....	......	......
Germanium	900	5.48	13	72	....	....	......	......
Uranium	900	18.7	13	240	....	....	......	......
Calcium	800	1.6	25	40	....	....	......	......
Didymium	800	6.5	22	142	....	....	......	......
Cerium	700	6.6	21	140	....	....	......	......
Aluminum	600	2.6	11	27	38.86	....	......	......
Strontium	600	2.5	35	87	....	....	......	......
Lanthanum	600	6.1	23	138	....	....	......	......
Magnesium	500	1.78	14	24	....	....	......	6077.5
Arsenic	500	5.7	13	75	....	....	......	......
Tellurium	455	6.4	....	126	....	....	......	......
Zinc	433	7.1	20	65	....	28.12 cal.	......	......
Antimony	432	6	18	120	....	5.858 cal.	......	243
Lead	326	11.3	18	206	....	....	......	......
Cadmium	320	8.6	13	112	....	13.6 cal.	......	......
Thallium	294	11.8	17	204	....	....	......	109.5
Bismuth	268	9.8	21	208	....	12.393 cal.	......	95.5
Tin	230	7.2	11	118	....	13.313 cal.	......	573.6
Selenium	217	4.8	16	73	....	....	......	......
Lythium	180	0.59	12	7	....	....	......	......
Sulphur	114	2.07	15	32	....	....	......	......
Iodine	114	4.09	26	127	....	....	......	......
Sodium	96	0.98	23	23	....	....	......	3293
Potassium	58	0.87	45	39	....	....	......	......
Rubidium.........	39	1.5	57	85	....	....	......	......
Cresium	27	1.88	75	133	....	....	......	......
Mercury	39	1.36	15	200	....	2.82 cal.	......	105.5

mass of the hydrogen atom, and is called a corpuscle. Whether we produce the corpuscles by cathode rays, by ultra-violet light, or from incandescent metal, and whatever may be the metal or gases present, we always get the same kind of corpuscles.

The ratio of the velocities of the negative ion produced by an incandescent metal depends very largely upon the temperature, *i. e.*, the higher the temperature, the greater the velocity of ions. *Corpuscles moving at a high speed through a gas make it luminous.* Consequently, the higher the temperature of vaporization, the more thorough will be the process of ionization, the more rapid will be the motion of the corpuscles, the more simple will be the spectrum and the more light will be developed.

The ionization takes place at the surface of contact between the metal and gas in the arc. There is a potential difference between the metal and gas. In order to transfer the unit of negative electricity from the metal to the gas, work must be performed equivalent to the potential difference. The larger this potential difference will be the less electropositive will be the metal, the more energy must be expended for the dissociation, producing light, the less sensitive towards photoelectric influences will be the metal. This explains the fact that the most positive metals are the most sensitive photo electrically.

While discussing the physical properties of elements, we may point out here their comparative heat and electric conductivity, having a marked effect on the phenomena of the arc.

The heat conductivity of carbon is about 37 times weaker than that of the poorest conductor of heat among the metals, *i. e.*, its heat resistance is 37 times stronger.

The electric resistance constant of carbon is $\int$ variable between 100 and 1,000 in ohms. Table 4 gives the specific resistance of metals calculated according to Landolt and Bernstein.

The electric conductivity of metals is almost proportional to heat conductivity (Wiedman and Franz). Lorenz finds that in metals at 0 degrees just as well as at 100 degrees C. $\int$ is nearly constant with good conductors. However, with poor conductors this ratio grows with diminishing conductivity.

The average value for $\int$ is 4.

	Cu.	Zn.	Fe.	Hg.	St.
$10^{-2} = 1.6$	1.7	1.7	1.7	1.8	1.8

Arc light carbons = 0.493 to 0.367.
" " " $k = 2670.88 \; 10^{-9}$ to $146{,}032 \; 10^{-2}$.
" " " $\ell = 1.844 \; 10^{-6}$ to $2.509 \; 10^{-6}$.

TABLE NO. 4.

SPECIFIC RESISTANCES OF METALS CALCULATED ACCORDING TO LANDOLT AND BERNSTEIN.

Metals.	$\int$	$\triangle\int$
Aluminum	0.05	+0.0039
Antimony	0.5	+0.0041
Lead	0.22	—0.0041
Cadmium	0.07	+0.0041
Iron	0.1-0.12	+0.0045
Gold	0.02	+0.0032
Copper	0.18-0.019	+0.0039
Magnesium ...	0.04	+0.0039
Nickel	0.15	+0.0037
Platinum	0.12-0.16	+0.0024-+0.0035
Mercury	0.95	+0.00091
Bismuth	1.2	+0.0037
Zinc	0.06	+0.0042
Tin	0.10	+0.0042
Carbon	100-1000	+0.0003-—0.0008
Silicon	0.016-0.018	+0.0034-+0.004

$\int$ = the electric resistance constant of carbon variable between 100 and 1000 in ohms.

$\triangle\int$ = the change of $\int$ for each degree in parts between 0° and 30°.

The ability of metals to conduct heat is very nearly the same as their ability to conduct electricity. The order of metals in these two series is almost identical. Further, the specific conductance of heat is almost analogous to the specific conductance of electricity. Table 5 gives the thermal resistivity of various materials in c. g. s. gram calories units, also

the thermal conductivities in units which are reciprocals to resistance.

Metals melting at a comparatively low temperature and showing a high affinity for oxygen are non-arcing. The products of oxidization of metals are in many cases very poor conductors of electricity, as for instance of aluminum and magnesium. Being good conductors of heat the gases comprising the luminous arc cool down rapidly. *Hence it is a great deal harder to relight an extinguished metallic arc, than a carbon arc.* The good conductivity of heat by metals is especially troublesome in alternating current arcs.

TABLE No. 5.

TABLE OF THE THERMAL RESISTIVITY OF VARIOUS METALS IN GRAMM CALORIES UNITS, ALSO THE THERMAL CONDUCTIVITIES IN UNITS WHICH ARE RECIPROCALS TO RESISTANCE.

Metals.	Cond. in Reciprocals of Res. Units.	Resistance in C. G. S. Gramm Calories Units.
Silver (0°)	1.10	0.91
Copper (0° to 30°)....	0.92	1.09
" commercial	0.82	1.22
Magnesium	0.38	2.63
Aluminum (0°)	0.34	2.94
" (100°)	0.36	2.35
Zinc (15°)	0.30	3.33
Tin (15°)	0.15	6.67
Cadmium (0°)	0.20	5.0
Iron, wrought (0°)....	0.12	4.76
" " (100°) .	0.16	6.25
" " (200°) .	0.14	7.14
Lead (0°)	0.084	11.19
" (100°)	0.076	13.16
Antimony (0°)	0.044	22.75
Mercury (50°)	0.019	52.63
" (100°)	0.024	41.67
Bismuth (20°)	0.018	55.55

The Voltaic arc is characterized by a considerable fall of potential between the electrodes, a fall which shows, that the production of the arc requires a considerable expenditure of energy. This difference of potential depends upon the nature of the electrodes as well as on the diameter and on the length of the arc.

It is given according to Edlund by the equation V = A plus bl, "a" and "b" being constants and "l" the length of the arc. "a" is an electromotive force opposed to the direction of the current. *As known resistance to the passage of the current plays an important part in the production of the voltaic arc, the fall of potential takes place principally at the passage of the current from the positive carbon to the air in the carbon arc, and from the negative electrode into the air in the metallic arc.* The potential remains constant in the layer of gases included between the two electrodes even at a considerable distance from the axis. *This discontinuous variation of potential only takes place with carbon electrodes, and is not found with metallic electrodes.*

V. Von Lang (Wied. An. 31, p. 384, 1897) determined the tension of different metallic electrodes and expressed them by means of Froehlich's formula. The constant "a" in this formula called by V. Von Lang the counter electromotive force of the arc, represents the tension below which no arc can be maintained.

Metal.	Constant "a."	Melting Point.
Platinum	27.41—1.16	1775
Nickel	26.18—2.95	1350
Iron	25.03—2.16	1400
Copper	23.86—1.33	1034
Zinc	19.86—2.27	403
Silver	15.23—0.45	950
Cadmium	10.28—3.28	320

With the exception of silver *the constant "a" increases in direct proportion to the point of fusion.*

For carbon, having the highest melting point, the constant "a" is the highest, namely: 40 volts. Titanium ought to have a constant "a" near to it. Gay and Monash [Arch. d. La Phys. et. Nat. (Geneva), (14), 15, 15, III, 1903], found that when the length of the arc and the current of the metallic arc are kept constant, the electric tension is higher in proportion as the atomic weight is higher. Table 6 represents the data procured, when the current was 0.24 amperes (alternating

period, 47 per second), and an arc of 5 mm. length was maintained.

Schulze (Diss. Hanover 27, XI, p. 25-31), demonstrated, that *the groups of the periodic system possessing higher atomic weights and higher melting pints are distinguished by a comparatively high drop in potential at the arc,* and especially a larger resistance of the anode. Schulze claims, that within the same group the loss of tension in the arc is decreasing with the increase in the atomic weight (Alkaline earths).

As the metallic arc in the open air is a result of incandescence due to both the resistance to current and chemical causes due to oxidization, the study of mercury arc in a vacuum is highly instructive.

TABLE No. 6.

TABLE OF DATA PROCURED ON THE ELECTRIC TENSION OF THE METALLIC ARC.

Metal.	Atomic Wt.	Tension.
C	12	640
Mg	24	700
Fe	55.9	850
Ni	58.6	850
Cu	63.2	870
Ag	107.7	900
Cd	115.5	725
Pr	194.3	1000
Au	196.7	1040

D. E. Weintraub claims that the resistance of the arc can be considered as inversely proportional to the current. In contradistinction to the ordinary arc of carbon, the voltage of the mercury arc varies in the same sense as the current. He distinguishes three kinds of mercury vapor in the arc stream; one ionized and conductive, the other non-conductive, but light emitting, and third, non-conductive and non-luminous ordinary mercury vapor.

The material of the anode does not seem to affect the nature of the mercury in the least.

The luminosity is a function of the temperature of the gases forming the arc. In connection with this conclusion Child's data concerning the comparative resistance of the metallic electrodes is of great interest.

Metal.	Resistance of Anode in Volts.	Resistance of Cathode in Volts.
Zinc	12	14
Iron	13	15
Copper	11	14

Certain compounds possessing high vaporization points may be used as a source of light. The first attempt in the direction of utilizing highly refractory material for light-giving purposes was made by Jablochkoff, whose "candles" at one time aroused the interest of all the civilized world. Nernst perfected this idea in the shape of his well-known filament. As with the metallic arc the cathode is the active element. The fact, that highly refractory compound bodies are conductors of the second class, *i. e.,* that they belong to the category of bodies conductive only at comparatively high temperatures, rather limits their usefulness.

Let us now recapitulate the principal points of difference between the carbon or incandescent arc and the metallic and luminescent or electrolytic arc, and also the flaming arc.

The carbon arc concentrates the half of its light in one point of the positive electrode called the crater, while the negative electrode remains more or less passive. The lower electrode obstructs the most luminous part of the arc and hinders the uniform distribution of light. The new lamps for impregnated carbons are constructed with the intention of eliminating this effect by returning to the Jablochkoff scheme of parallel carbons.

The luminous arc has no pronounced crater. All the arc is luminous and emanates from the lower negative carbon, while the upper positive is more or less passive and not consumed in the process of light giving. We may say either that the current is reversed against the arc or that the ions work against the current. The absence of an obstruction leads to a better distribution of light. About

55% of the light is distributed between 0 and 20 degrees and about 20% below the horizontal line. The efficiency of the metallic arc of the electrolytic arc is a great deal higher than the efficiency of the carbon arc. The products of oxidization of carbon arc are gaseous, while of the metallic or electrolytic solids.

Numerous attempts to combine two oxides of which one would act as a-conductor and the other as a light producer failed.

The magnetite lamp, so called, is an example of such attempts. The electrode is an iron tube filled with a powdered mixture of about 25% titanic acid, about 5% iron chromate and black oxide of iron with some potassium fluoride.

In order that "magnetite" be able to compete with carbon pencils, it must have the following properties:

The mass of the pencil must be homogeneous, and compact throughout every part of the pencil, in order to give a steady, luminous and uniform arc. The necessity of homogeneousness is apparent from the following: Take, for instance, a copper rod, solid all through, and compare it, with a copper tube filled with copper filings of different sizes:

Now, the difference in the conductivity between these two bodies will be striking (leaving out of the comparison the conductivity of the tube which contains the filings). This difference in conductivity must prove a great disadvantage in the case of the tube filled with filings, for the reason, that the lower conductivity of the filings will tend not only to increase the expenditure of energy necessary for the production and maintenance of the arc, but will cause constant flickering and fluctuation of the incandescent gases, in the effort of the current to overcome the varying resistances of the different particles having various dimensions and separated from each other in varying distances.

In order to overcome the high and varying resistance of the so-called magnetite powder, they, the manufacturers have been obliged to use an iron tube not only as a means of enveloping the powder but as a means of conductivity. The result is, an increase of fluctuation, of the arc, due to its tendency to seek the path of least resistance, which is in this case, the iron tube, consequently the arc changes its nature entirely, every time it moves from the tube to the "magnetite" powder. It is self-evident that an iron arc is highly undesirable.

If the arc was produced from a homogeneous body, for instance, magnetite, titanic acid, titanium carbide, or iron chromide, the arc would be homogeneous as to its nature and color. Even in the case of these different ingredients being thoroughly mixed with each other to a more or less homogeneous powder and by mechanical or other means, compressed into a solid body, without the use of the iron tube, the arc produced under these conditions could not, by any means be of a definite homogeneous type and color. But when these bodies are only loosely packed in an iron tube, the arc must be a composite arc of all these varying bodies, resulting in a continuously conflicting arc between the component elements.

In order to eliminate the undesirable properties of the so-called magnetite pencils, it is necessary to consider:

1st. That the chemical composition of the body of the pencil should be changed so as to make it homogeneous.

2nd. The physical condition of the pencil should be changed to make it compact and conductive without the aid of any contrivances in the shape of a tube.

3rd. Magnetite itself is a comparatively poor conductor of electricity, and gives an arc of low luminosity and undesirable color.

4th. Magnetite contains gangue which is not easily removed and produces undesirable results in the arc.

5th. There is constantly occurring in the magnetite arc a higher oxidization into red oxide of iron which again lowers the luminosity of the arc.

6th. Titanic acid is a very poor conductor of electricity. It may be the only element in the body of the pencil which is desirable, as a light producer. However, taking into consideration its high resistance, the quantity that can be added to the pencil is rather limited; consequently the luminosity of the pencil due to the presence of titanic acid cannot be raised above a comparatively low luminous value.

7th. Titanium carbide is decomposed in the arc and consequently cannot give a desirable light.

Taking all in all the so-called magnetite pencil cannot be by any means made a success as a light-producing agent, leaving aside all question of lamp mechanism, cost of trimming, etc. Baking the mentioned ingredients into a solid pencil gave more satisfactory results.

Among all metals titanium furnished the best material for arc light electrodes. Next to iron it possesses the richest spectrum as far as the number of lines is concerned. Titanium excels all non-rare metals in the nature and extent of the light-giving part of the spectrum. Thalen counted 201 lines in the red part of the spectrum out of 6,556, about 4,163 in violet. Liveying and Denar counted between the same four new ones and Corner twenty-five in the ultra violet, together 230 lines. In the red part are only two, in the orange 17, in the yellow 32, in the green 70, in the blue 35, in the indigo 45, in the violet 4 lines. 118 are Frauenhoffer lines recognized in the photosphere of the sun. 32 of these are artificially restored by Liveying, and Dewar to their actual state. Being a poor conductor of electricity, titanium can be used advantageously as material for arc-light pencils only in its combination with a metal having a comparatively high electric conductivity as iron, copper, etc. The combination of titanium or any other luminiferous body of low electric conductivity with a metal having a high electric conductivity but poor luminosity is what the writer of these lines claims as his invention. Any mechanical mixture of titanium compounds with more or less conductive bodies, for instance, a mechanical mixture of rutile, with magnetite, must necessarily fall short of the requirements of a good illuminant, as is demonstrated by the so-called magnetite lamp.

The electrode of the magnetite lamp represents an iron tube filled with about 25% of titanic acid, some chromate of iron and potassium fluoride and magnetite. The light-giving element is, of course, not the magnetite, but the rutile. The chromate increases the life of the pencil, while the potassium salt quiets the arc. That the presence of so many ingredients in mere mechanical combination must produce an undesirably complex electrode is self-evident.

Experiments with reduction of the surface of these electrodes or electroplating it with iron or copper to improve the properties of the pencils failed. The partial reduction undoubtedly increased the flickering and unsteadiness of the arc and did not in the least reduce the extreme brittleness of the pencils. The proportion of the ingredients used for the manufacture of the solid pencils was about 80 parts of magnetite or scale, about 20 parts of hematite and about 7 or 8 parts of titanium oxide. More than 9 or 10 parts of titanium oxide could not be added to the mass of the electrodes without producing a very unquiet and flickering arc. The ingredients were finely pulverized in ball mills and then mixed with water, glycerine or similar binding material in paint mills during 48 hours. The thoroughly mixed mass was freed from excessive moisture by the means of revolving cylinders heated by steam. The plastic mass was then moulded into pencils under a pressure about 500 atmospheres by the aid of a hydraulic press. The pencils were gradually dried at first in the air, then in an air bath at a temperature not exceeding 5,000 or thereabouts. Finally the pencils were fired gradually in a gas furnace at a

temperature not exceeding 1,200 degrees to 13,000 degrees C. Experience showed that the firing of the electrodes at a comparatively higher temperature increased the luminosity but shortened the life of the pencils. A slight addition of boric acid to the mass of the pencils seemed to lengthen their life and impair their luminosity, which was probably due to some chemical combination (slag) or boric acid with the oxides. The addition of other chemicals intended to quiet the arc, as, for instance, potassium titanite, potassium carbonate, etc., appeared to me to produce no results whatever on the arc.

The resistance of the baked pencils of about 0.5 inch in diameter and five inches long is from 44,700 to 624,800 ohms. When covered with a thin film of graphite the resistance of the same electrodes fell to 4.88 ohms or 6.24 ohms.

In order to determine the difference in the behavior of the pencils according to their conductivity, a number of them were partially reduced in carbon at 1,150 degrees C. Their resistance varied from 11 to 28 ohms. Pencils heated without carbon at the same temperature at the same time showed a resistance varying from 594,000 to 9,830,000 ohms. As the degree of reduction seemed to me to play some rôle in the arc—I made a few experiments to determine the influence of the process of oxidization in the arc. Electrodes for these experiments were prepared in the usual way and manner. One batch contained the usual proportion of hematite and magnetite. The second batch did not contain any hematite at all. The third batch did not contain any magnetite at all. All of these three batches contained an identical quantity of titanium oxide (of 7.5 parts), and all were treated at the same time under exactly the same conditions, as far as practicable. The most luminous arc was produced by the pencils containing only magnetite and titanium oxide. The least luminous arc was produced by the pencils composed only of hematite and titanium oxide. The mixture composed of 80 parts of magnetite and twenty parts of hematite produced an arc of medium luminosity. As hematite represents the final product of oxidization of iron, the conclusion was near at hand that *oxidization is a factor favorable for the luminosity of the arc, i. e.,* the more space there is left for the oxidization of the material of the electrodes in the arc, the higher must be the luminosity of the arc. For the purpose of verifying this conclusion, additional experiments were conducted. Electrodes of the identical batch were subjected to various degrees of reduction and the luminosity of their arc tested. In each case the more reduced pencils gave a higher luminosity and the luminosity of the perfectly reduced pencils was about double that of the luminosity of the non-reduced pencils of the same batch. A batch containing 50% magnetite and 50% titanium oxide were subjected to various degrees of reduction with the following results:

Well reduced pencils produced an arc of a luminosity equal to...1271 c.p.
Partly reduced pencils produced an arc of a luminosity equal to...1000 c.p.
Poorly reduced pencils produced an arc of a luminosity equal to... 868 c.p.
Not reduced pencils produced an arc of a luminosity equal to... 700 c.p.

All these are horizontal measurements. The current used was a direct one of 150 volts, 3.4 amperes, with 105-110 volts drop across the arc. The volts of the standard were 30.1 of 63 c.p.

The reduction not only about doubled the efficiency of the arc, but allowed the use of high percentages of titanium oxide in the mass of the pencils. In the non-reduced or partially reduced pencils an addition of about 10 parts of titanium oxide was excluded, because it caused the arc to flicker to such an extent that no photometric reading could be taken with any degree of accuracy, if at all. The arc of the reduced pencils did not flicker very badly when even as high as 90% of titanium oxide was used in addition to 10% of magnetite as the

mass for the pencils. There appears, however, to be a limit beyond which any further addition of titanium oxide is hardly advantageous. The maximum efficiency of the arc is obviously not the only thing to be considered in our case. The best result I obtained was with pencils containing about 50% of titanium oxide or 50% magnetite. The perfectly reduced electrodes are metallic through and through, harder than tool steel and take an excellent polish. When ready for use they look like ordinary steel cylinders.

Obviously, any luminiferous substance may replace the titanium oxide and any metallic oxide the iron oxide. For instance, magnesium oxide could be combined with an oxide of copper and then reduced to metallic state.

One more step in the direction of perfecting the metallic-electrolytic arc was suggested by my work in that line, namely: that an alloy of titanium with a well conducting metal like iron, copper, etc., would furnish an ideal material. However, I had considerable trouble in getting titanium alloys. After many months of futile correspondence with various chemical dealers, metallurgists and general chemists, I finally was brought face to face with Dr. A. Rossi. This gentleman spent a great deal of work, time and money in his successful attempt to manufacture ferro-titanium, copper titanium and other titanium alloys on a commercial scale. Dr. Rossi owns a number of patents protecting his process of manufacturing titanium alloys and besides this, owns an exclusive right on titanium alloys "as a subject of manufacture." The chief market for his ferro-titanium is comprised by the iron and steel trade, titanium having the property to purify and harden the iron and steel.

After having procured from the above-named gentleman various samples of titanium alloys, I prepared pencils out of them and tested their fitness for the electric arc. The results more than justified my expectations. Comparatively small quantities of titanium alloyed with other metals obscure the spectrum of the last and produce an arc, whose luminosity is entirely out of proportion to the quantity of titanium contained in the mass of the pencils.

Alloys of other metals, whose oxides are distinguished by their higher luminosity in the arc, as for instance, magnesium, zirconium, etc., with non-luminiferous but conductive metals produce similar results. I feel, therefore, justified to believe that my work here briefly outlined opens a new field for the metallic or rather the metallic-electrolytic arc, as a source of light of the future.

In order to ascertain the technical value of my invention, I investigated a few samples of my arc light pencils. The samples were designated as follows:

B—2 pieces marked F.T.—80% ferro-titanium.

C—1 piece marked 41 L—30% rutile, 70% magnetite.

E—½" national plain carbon, moulded.

The tests of the pencils were conducted at the laboratory of the Lamp Testing Bureau.

Tests were first made in a hand-fed arc lamp on a direct current circuit from a storage battery of 60 cells, giving 120 volts, approximately. Owing to the peculiar nature of the arc, it was found impossible to maintain an arc in this style of lamp much above ⅜" in length, and from 48 to 55 volts.

The results of the candle-power measurements and life tests of the ferro-titanium (B) and rutile (C) pencils as well as test made on a plain open arc domestic carbon, are summarized in Table 7. These tests are principally valuable as illustrating the nature of the pencils, and relative illumination and life as compared to an ordinary carbon when operated under the same conditions. The results as tabulated are the averages obtained.

The average results given were mostly obtained with a positive carbon pencil above. The results with a positive copper pencil above were slightly

lower in candle-power, but not materially so, and were averaged with the other results obtained.

The positive copper pencil is evidently not consumed in the arc when used in connection with the titanium pencils. There is a slight loss in weight, probably due to oxidization and sealing at the surface of the copper owing to its high temperature.

The rutile pencil was further tested in a constant potential arc lamp operating on a current of 4.5 amperes, approximately. In this lamp the rutile pencil (C) was placed below ordinary carbon above, and the test made first with the carbon as a negative and then with it as a positive. As the rutile pencil could not be placed in the upper holder in the lamp for purposes of comparison, a further test was made in the hand-fed lamp, using rutile pencils both above and below with the upper pencil positive. Two sets of measurements were made, one at 60 volts, approximately, and the other at 70 volts. The results are tabulated in Table 8.

TABLE No. 7.

RESULTS OF TESTS IN HAND-FEED ARC LAMP.

At 3.5 Amperes.	"B" Ferro Titanium.	"C" Rutile.	"F" Plain Carbons.
Mean spherical candle-power	510	283	84
Watts per candle-power	.579	.701	2.5
Amperes	3.51	3.51	3.5
Volts	48.3	55.8	49.1
Watts	169.4	195.4	171.4
Length of arc, inches (estimated)	.375	.350	.125
Life of negative, hrs. per inch	3.85	11.1	2.8
Dir. of pencil, inches	.57	.52	.50
Resistance per inch—ohms	.00164	.00284	.0846
Weight per inch, grammes	9.64	14.33	4.83
At 6. 6 Amperes.			
Mean spherical candle-power	968	737	243
Watts per candle-power	.341	.436	1.35
Amperes	6.6	6.6	6.6
Volts	49.5	48.7	50.1
Watts	326.7	321.4	330.3
Length of arc, inches (estimated)	.400	.375	.180
Life of negative, hrs. per inch	1.1	1.96	1.7
At 9.6 Amperes.			
Mean spherical candle-power	1135	Fused ex-	485
Watts per candle-power	.330	cessively	.986
Amperes	9.6	with 9.6	9.6
Volts	39	amperes.	50
Watts	374.4	....	480
Length of arc, inches (estimated)	.375	....	.190

TABLE No. 8.

RESULTS OF TESTS WITH RUTILE PENCILS.

At 60 Volts.	Carbon Upper — Rutile Lower +	Carbon Upper + Rutile Lower —	Rutile Upper + Rutile Lower —
Mean spherical candle-power	54.4	448	624
Watts per candle-power	5.21	.61	.41
Amperes	4.52	4.18	4.25
Volts	62.8	62.8	61.2
Watts	283.9	270.9	260.1
Length of arc (estimated), inches	.75	.75	.70
At 70 Volts.			
Mean spherical candle-power	46.9	590	1015
Watts per candle-power	6.63	.56	.30
Amperes	4.35	4.35	4.30
Volts	71.5	72	70
Watts	311	314	301
Length of arc, inches (estimated)	.875	.875	.75

The light distribution in the tests of the ferro-titanium, rutile and carbon pencils at 3.5 amperes and from 50 to

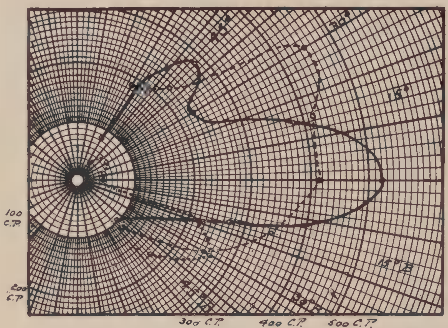


FIG. I.—DISTRIBUTION CURVES OF FERRO-TITANIUM, RUTILE, AND CARBON ELECTRODES IN A HAND-FEED ARC LAMP.

55 volts are shown in Fig. 1. The light distribution of the test of the rutile pencil in a constant potential lamp at 4.2 amperes and 70 volts is shown in Fig. 2.

All candle-power measurements were made on the arc photometer designed by Prof. Matthews. The life of the results is computed from a burning test of from one and one-half hours to two hours, the pencils being first burned to share and then weighed in a chemical balance before and after the test.

For the purposes of comparison I have plotted on sheet 2 a curve "F" taken from the report of Prof. C. P. Matthews, included in the report of the Committee on the Photometric Measurements of Arc Lights to the National Electric Light Association, May 20, 1902. This curve is the result of many measurements and represents series enclosed arc lamps in common use in this country for street and interior illumination. The measurements were made on a constant current of 6.8 amperes with 70 volts at the arc, with an opalescent inner and a clear outer globe. In interior illumination an opal or an opalescent outer is usually substituted for a clear outer. The constant potential enclosed arc lamp is also used for inside illumination, but its light distribution curve for the same energy consumption does not differ from that shown.

The series enclosed arc lamp gives 303 mean spherical candle-power at 476 watts or 1.57 watts per mean spherical candle-power. They burn approximately 10 hours for one trimming.

The light produced by ferro-titanium and rutile (oxide of titanium and magnetite), pencils is a pure white as judged by the eye. The spectroscope shows the entire solar spectrum with especial brilliancy in the bright yellow portion and the neighboring light green and orange. The size and length of the arc, which produces most of the light, softens the sharpness characteristic of the open carbon arc.

The arc itself presents many peculiarly characteristics and assumes difliar characteristics and assumes diftions. The normal arc with a positive

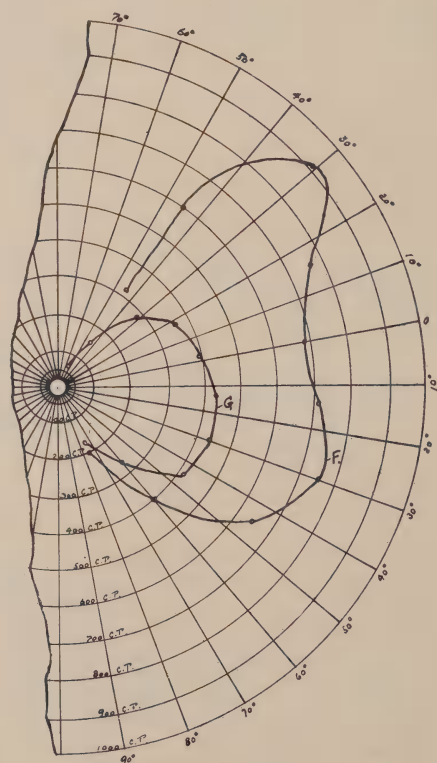


FIG. 2.—CURVE F, DISTRIBUTION OF A RUTILE ELECTRODE; CURVE G, CARBON ELECTRODE.

copper or carbon pencil above and the ferro-titanium or rutile pencil below is approximately 4/8″ in length at from 50 to 55 volts, and increases to 3/4 or 7/8″ at 70 volts. It is from 3/32″ to 1/8″ in diameter and seems to emanate from the titanium pencil. At the higher voltage the arc is very unstable, and is easily broken. At from 50 to 55 volts the familiar sound of a "hissing" carbon is produced. As the voltage and the length of the arc is increased, this sound is diminished and the only sound produced is the one of escaping steam, but this is not of an objectionable character.

Under both the above conditions of operation, the point of contact of the arc with the upper and lower pencils is constantly shifting, which causes a flutter in the light emitted. The objectionable features of this are largely eliminated with a long arc, and probably would be unobjectionable with the arc protected by an opal or opalescent globe.

The life tests were made at from 50 to 55 volts, a much lower voltage than that at which the pencils are designed to operate. Therefore, while these tests are indicative of the results to be expected at 100 volts, the life at 100 volts cannot be predicted upon them. From these results, however, and from actual tests made with the necessary special apparatus by Mr. Ladoff and certified to by others engaged in the tests, it seems safe to estimate the life of a rutile pencil ½″ in diameter, to be from 10 to 12 hours per inch—perhaps higher.

There should be no difficulty, therefore, in proportioning the size and length of the pencil to attain a life of 100 hours, the normal life of the enclosed carbon arc lamp with one trimming. As the arc under proper conditions can be maintained at from ¾″ to an inch in length, by increasing the diameter of the titanium pencil, the burning hours for one trimming, could be very materially increased. I am informed that this has actually been done and a very much higher life obtained.

As already mentioned, when the titanium pencil is made the negative and placed below, at 70 volts, the arc is from ¾″ to ⅞″ long and about ⅛″ in diameter, and of an unusually white color, slightly more light being produced at or near the surface of the electrodes, owing to the concentration of the arc and the incandescence of the surfaces. The arc itself is clean cut and well defined, and is a true arc and not a flaming arc, as is generally understood by that term. The same results were obtained with either a copper or carbon positive. As already mentioned, the arc fluttered and shifted constantly. The apparent trend of the arc and the gases and material carried by it was, under normal operation, from the negative to the upper positive pencils. Under the same current reversed, that is, the lower titanium pencil made the positive, an arc of entirely different character was obtained. The diameter of the arc was increased from 1/8″ to 1/4″ or 5/16″. At the same voltage the length was also slightly increased, approximately to one inch. The "flutter" noticed as above mentioned was absent, although the arc lazily shifted from one point to another. The direction of the arc still seemed to be from the lower positive to the carbon or copper negative above, but possessed but very little illuminating power, and had a decidedly reddish tinge. Frequently, for short intervals, the arc became suffused with the white light characteristic of titanium. On account of its steadiness, lack of "fluttering" and very large diameter and length, the arc presents many attractive features.

By placing the titanium pencils on both sides of the arc and making the upper electrode positive, a third arc of a distinctly different character was obtained, though differing from either, it seemed to be practically a combination of the two above mentioned. The arc resembled an inverted cone in shape with the apex on the lower rutile negative pencil, and the base on the upper pencil. Through the center

ran a core fairly representing the arc obtained in the first case above mentioned. Around it was a zone representing the second arc described but increased in diameter to possibly 5/16 or 3/8" and suffused with the white titanium incandescent gases. The arc as thus obtained was absolutely steady with no fluttering or shifting. Both upper and lower pencils were fused at their surfaces, but contrary to expectations the moulten material from the upper pencil did not drop. The light is softened somewhat by the presence of what might be called the negative arc, but possesses all the color characteristics of the titanum arc. The measurements made of these three arcs have been given on page 45, from which it is seen that the candle-power efficiency is nearly doubled at 70 volts by placing the titanium pencil above as well as below.

An efficiency of .3 watt per *mean spherical candle-power*, was obtained in this test, and it seems entirely probable that this can be improved.

In Fig. 3 I have plotted the watts for mean spherical candle-power obtained at 50 volts approximately, with ½" pencils, and at various current values. It is apparent from the curves there shown, that there is very little increase in efficiency resulting from an increase of current above 6 amperes, under the conditions observed in the test, viz., with ½" pencils and about 50 volts at the arc.

In Fig. 4 I have plotted the results obtained at 60 and 70 volts, with a rutile lower negative, and a positive

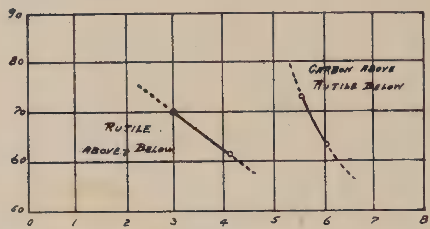


FIG. 4.—EFFICIENCIES WITH COMBINATIONS OF ELECTRODES.

electrode of carbon and rutile respectively. Unfortunately the number of observations were not sufficient to construct a reliable curve, but the sheet indicates graphically the great increase in efficiency due to using a titanium positive as well as negative, and from the direction of the curves, it indicates that an increased efficiency would be obtained at a higher voltage, especially in the case where the titanum is used for both positive and negative electrodes.

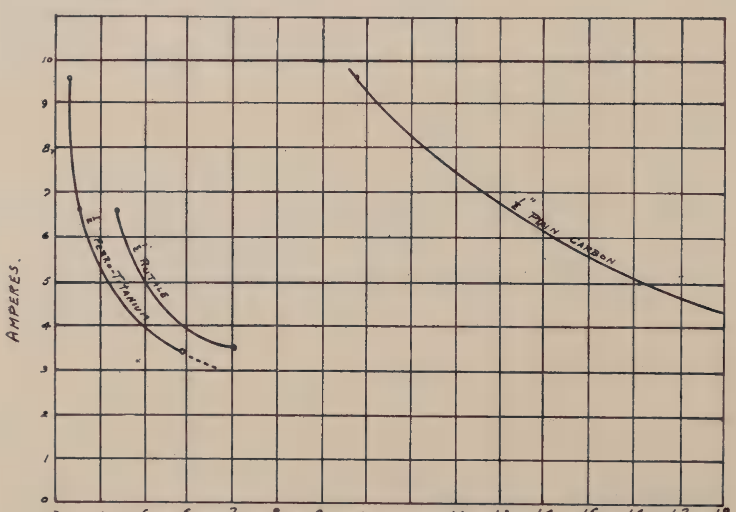


FIG. 3.—EFFICIENCY CURVES FOR FERRO-TITANIUM, AND CARBON ELECTRODES.

The Illumination of the Early Christian Churches

The only distinct form of architectural design which has always been inseparably connected with a particular use, is that known under the general title of "Gothic." This style arose in the early days of the Christian Church, succeeding the Roman modification of Greek architecture which was used in the Basilica, as the first Christian Church edifice in Rome was called.

Probably in no other class of building has there ever been so great a devotional spirit given to the design and construction as in the Gothic Church, especially those of early dates. From the architect himself down to the humblest workman, there was a spirit of religious devotion which wrought itself into every phase and detail of the building. The means of illuminating these edifices expressed this feeling of religious consecration.

The following description of some of those early lighting fixtures is of interest historically, and may possibly suggest ideas to those having in charge the designing of churches at the present time. The description and illumination are from *"Histoire du Luminaire,"* by Henry-Renè d'Allemagne; a beautifully printed and illustrated volume tracing the development of illumination from the Roman epoch to the end of the nineteenth century. It was published in Paris in 1891, but is now exceedingly rare.

THE EARLIEST FORMS OF CHANDELIERS.

The oldest forms of chandeliers were constructed in the shape of a circle; and we have seen in the Catacombs, the *rota* figuring among the apparatus used for liturgical illumination. In the primitive church these chandeliers were of very moderate proportions, and were constructed in harmony with the edifices in which they were placed. These soon became insufficient, however, and were later constructed of larger proportions to correspond with the magnificence of the buildings. These circular chandeliers or "crowns" enjoyed their greatest vogue in the twelfth century, and the finest specimens of this class belong to this epoch. In the Middle Ages, these crowns were given various names, such as Coronæ, Pharæ, Circuli Luminum, Polycandelæ, etc. These fixtures were suspended from the arches of the churches, and supported a considerable number of wax candles or lamps, which, in the imagination of a poet of the time, "rivalled the glory of the stars."

We know that these "crowns" were for a long time in use in the Latin Church; a reference to them appears in a hymn of this period. These fixtures were made of silver, copper, iron and wood. They were usually in the form of a circle of greater or less diameter, according to the number of lamps to be used, and were suspended by one or more chains, generally three. It is needless to remark that the lamps were small, giving a feeble illumination, in spite of their number. To produce a more impressive effect, the ancients used a great number of wax candles. From the specimens still in existence, we know that these crowns were ornamented with enamel, with glass bowls, with metal scroll-work, and with pendants which scintilated in the rays of the candles.

One of the rare specimens of this class which is in existence at the present time is the famous crown of Aix-la-Chapelle. As in the case of the seven-branched candle sticks, the artists of the twelfth century derived the motif of their designs from bibli-texts; thus, all of these chandeliers represented symbolically the celestial Jerusalem according to the vision of St. John. On this point, there is in-

disputable evidence in the form of an inscription which the Emperor Frederick Barberousse had engraved upon the chandelier of Aix-la-Chapelle.

This fixture is in the form of a circle, made of bronze gilded and enameled; the inscription being engraved upon the segments which divide it into eight lobes. In the reëntering angles of these segments are placed lanterns in the form of round towers, with large openings in the shape of doors, which up to the time of the French Invasion, served as niches for silver statuettes, which have since been destroyed. The spaces cut out of the large medallions forming the base give reason to believe that these towers also contained lamps, whose light glimmered through the metal work about the figures. This fixture was intended to support forty-eight candles regularly between the towers which, as may be seen, are sixteen in number, eight square

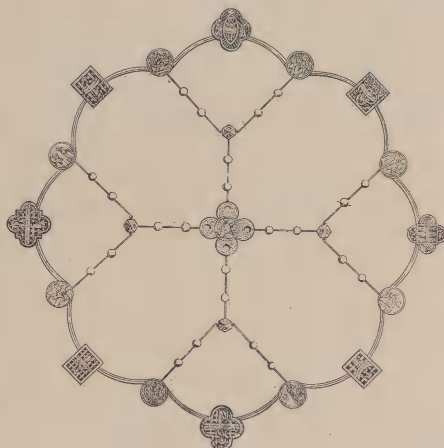
CHANDELIER IN THE CHURCH AT AIX-LA-CHAPELLE.

ENGRAVED METAL PLAQUE FORMING BASE OF LANTERNS.

and eight round. This interesting fixture is suspended from the center of the dome by a strong chain and ornamented with polyhedrons of copper at the points where the chain divides to extend to the eight subdivisions of the crown. An iron ring which has the same outline as the crown is covered on the exterior by a band bearing the inscription, and is painted on the interior in brown or yellow.

ENGRAVED METAL PLAQUE FORMING BASE OF TOWERS.

From the standpoint of workmanship this crown would seem rather to have been made on this side of the Rhine than on the other. There is not a single portion of it which does not contain details of remarkable delicacy. This extends even to the engraving on the copper in the lower part of the towers and lanterns. It is only when we give close scrutiny to these details that we appreciate the work which has been expended upon these fixtures. This state of preservation is such that we can follow the details in the illustrations, and thus,



PLAN OF THE CHANDELIER OF AIX.

with scrupulous accuracy, reproduce the subjects which they represent.

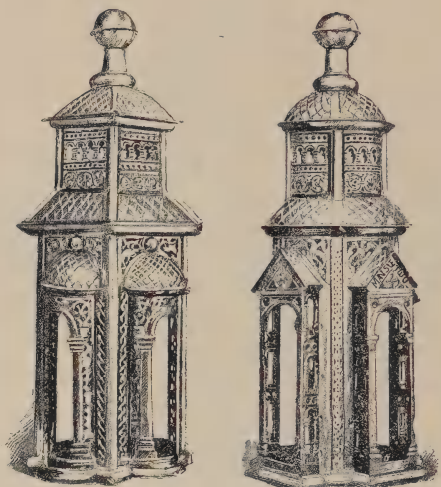
THE CROWN OF HILDESHEIM.

Although the crown of Aix-la-Chapelle is an example better known, and more often studied, it is nevertheless not the only one of its class. There are at Hildesheim two magnficent crowns of which the description is due to M. de Caumont, the only French amateur who, to our knowledge, has studied it in every particular. The result of his study is made the subject of a report in the 20th Volume of the *Bulletin Monumental,* and the best means of giving an exact idea is to reproduce this description:

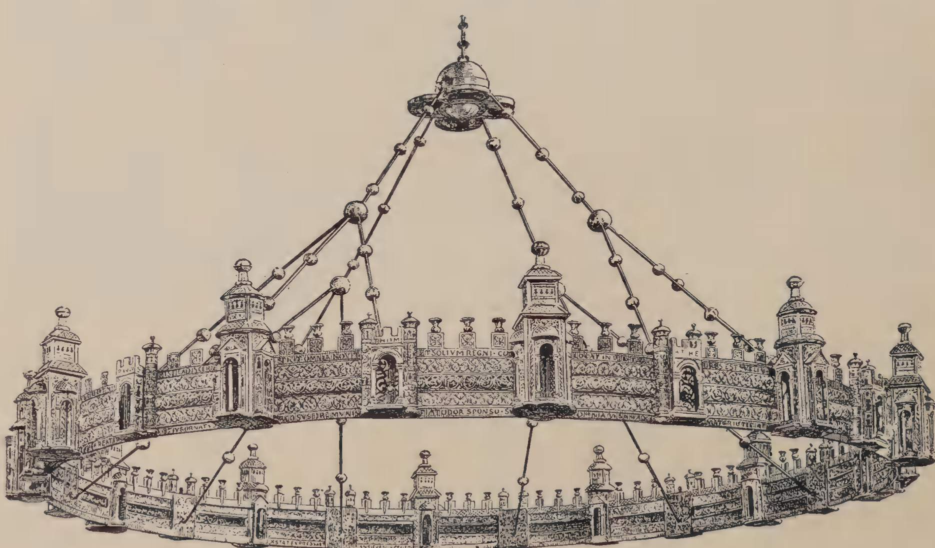
"The crown in the nave is the largest and most interesting. It is composed of circles of very large diameter,

carrying towers, and torches of gilded copper, on which are placed inscriptions in enamel; the filigree work of the circular band is in silver. The twelve towers are attached to the metal circles, as in that of Aix-la-Chapelle, in each of which are four silver statuettes representing personages of the Old Testament and personifications of the virtues, the names of which can be read across the towers. In the middle of the spaces between the towers are formed niches containing statuettes of the Twelve Apostles, with their names inscribed about them. There were sixty statuettes in the niches and towers which embellish the circles of this great crown. It is probable that lamps were placed on the tops of the towers. Between the towers six torches supported wax candles, of which there were seventy-two in all. A long Latin inscription engraved upon the circles shows that they represented the celestial Jerusalem. In the niches back of the statuettes were inscribed the names of prophets and the virtues which they symbolized.

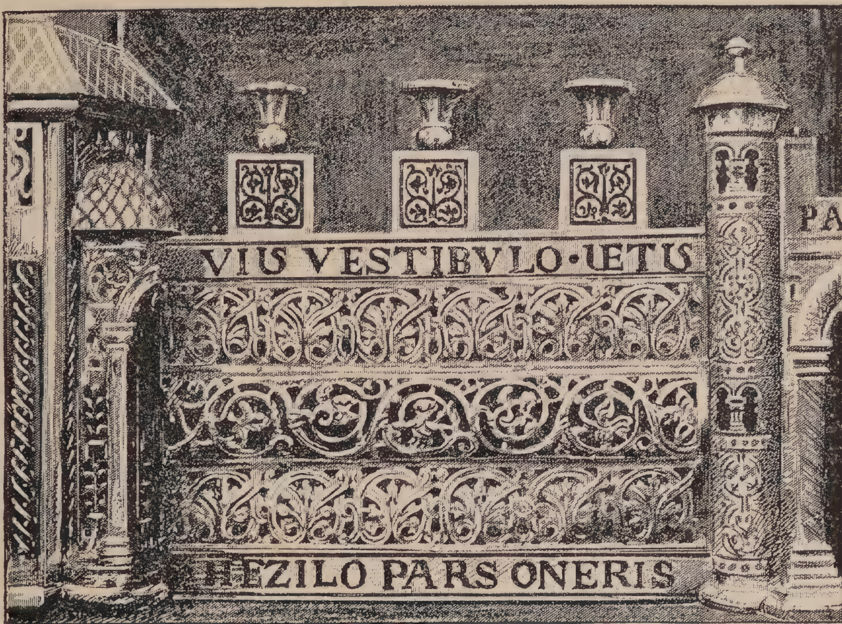
The second crown of the Hildesheim is in the choir of the Cathedral, which goes back to the eleventh century (Bishop Azelin, 1014-1054), but it is not as large as that in the nave. The spaces comprised between the towers bear only three torches, so that in all there are thirty-six in place of seventy-two. There were niches for forty-eight statuettes in bronze, which no longer exist. The two crowns of Hildesheim are suspended from the arch by means of a long chain, extending to an iron triangle, to which are attached the chains which extend to



LANTERNS, CROWN OF HILDESHEIM.



CROWN CHANDELIER OF HILDESHEIM.



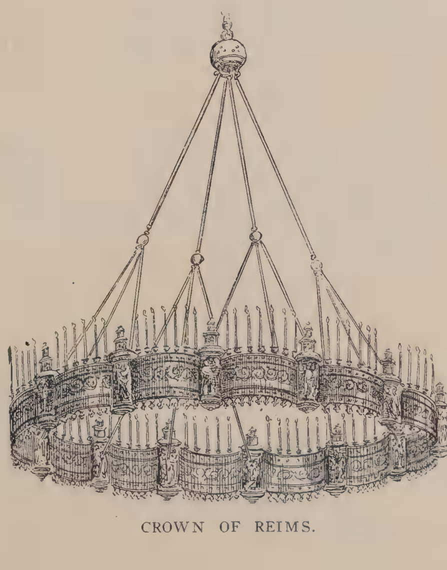
FILIGREE WORK BETWEEN THE LANTERNS AND TOWERS, CROWN OF HILDESHEIM.

the crown, as in that of Aix-la-Chapelle.

THE CROWN OF REIMS.

Before the Revolution we were at least as rich in these relics as our neighbors beyond the Rhine, having three specimens, as follows: One at Reims, one at Toul, and one at Bayeux. The crown of Reims existed up to the time of the Revolution. It was placed in the middle of the choir of Saint Remi de Reims, and was suspended from the arch by a chain, and supports ninety-six candlesticks of ornamental glass; its diameter was 18 feet. The band of copper out of which it was formed was divided into twelve parts, and each of these divisions was marked by a little tower opened at the bottom, and ornamented with crystal. The gospel according to St. John was engraved in Roman letters on the twelve parts of the band which formed the crown. The number of ninety-six candles seems to have had its origin in the rule of Cluny which the Benedictines of St. Remi followed. It directs the lighting of the ninety-six candles of the crown on the seven principal feast-days of the year.

The only picture of this fixture which at present remains is a plate of the sixteenth century, by the engraver Cellier, contained in a manuscript in the National Library.



CROWN OF REIMS.

THE ILLUMINATING ENGINEER

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THE PRACTICAL VALUE OF THEORETICAL SCIENCE

The delving into mysteries of science is looked upon by the average layman as the innocent but fruitless diversion of a certain class of peculiarly constituted men. It is an error, especially common in this country, to belittle, if not entirely to overlook the intrinsic value of the work of scientific investigators whose labors are almost entirely confined to the discovery of new facts and theories. The entire structure of modern manufacturing is founded upon the results of purely theoretical work; and upon the further development of such research must depend the future advancement of industry.

The great corporations have found that it is profitable to employ scientific investigators; but either the inducements offered, or the restrictions imposed, seem opposed to the highest achievements of scientific discovery in this manner. In fact, scientific discovery cannot be made to order with any more success than poetry can be written to order; the great scientific discoveries have been made, and are likely to continue to be made, by individuals working out their own particular ideas in their own free way.

The theory of the production of light, and the various phenomena connected with its production and use, form one of the most abstruse subjects of pure science. On many points in the theory scientists are by no means in general accord. Just why the chemicals forming the Welsbach gas mantle should afford so much more efficient light radiation than many other substances, such for example as the carbon, is one of these disputed points. The various theories and opinions given to account for this simple fact were well reviewed in Mr. Swinburne's paper which appeared in our last issue.

The discovery of new scientific facts, which have resulted in the recent improvements in means of generating light, are due almost entirely to European scientists, particularly those of Germany and Austria. The American mind seems to have lost, if indeed it ever possessed, the faculty of continued application to minute details which constitutes the chief requisite for successful scientific investigation. The American is too impatient for results, especially of results which can be expressed in dollars and cents, to allow of his following a particular line of research for its scientific value only.

Although some of the recently developed methods of producing light are revolutionary in character, the best of them are yet woefully inefficient in absolute results, and the field for improvement in this direction is still comparatively uncharted. Both from the scientific interest in the subject, and from the possible commercial value of results obtained, there would seem to be no more attractive field for scientists to work in.

In another part of this issue will be found a paper by Prof. Nichols, which gives a remarkably clear explanation of the various phenomena attending the production of light. There can be little doubt that the light of the future will make use of some of these phenomena, which at present are only known to the public as queer

sounding, incomprehensible scientific terms.

IMPROVEMENTS IN GAS LIGHTING

In our last month's issue we traced briefly the recent improvements in the means of producing light electrically, and expressed the opinion that these improved methods were so far in advance of those in present use as to be revolutionary in their effect. From the fact that little progress had been made in electrical lighting for a decade or more, the comparatively sudden appearance of a number of almost startling discoveries created all the more profound impression, and for the time being, at least, has rather eclipsed the steady, if less spectacular, advancement that is taking place in gas illumination.

The inverted gas burner was hailed with delight by gas engineers as supplying a means of meeting a phase of electrical competition which had previously been difficult, and in many cases impossible, to meet; viz., the greater adaptability of the electric lamp, and the wider range of decorative effects which it made possible. But, even among those particularly interested in gas illumination, there have been misgivings and doubts as to the ultimate success of this form of burner.

The inverted burner first came into public use in Europe, where conditions are somewhat different than in this country; and there is no doubt that these differences have been sufficient in many cases to counteract to a considerable extent the advantages which the burner possessed in its native field.

The conditions here, however, which have interfered with the utility of the inverted burner, are apparently reducible to two, viz., the supply of gas at a lower pressure, and poor regulation. These two conditions it would seem are sufficiently easy to adjust, if any material advantage is to be gained thereby. In other words, if a slightly higher pressure and better regulation is all that is needed to make the inverted burner the success which is claimed for it by the makers, and by many gas engineers, there would seem to be little excuse for not complying with these conditions in this country.

The inverted burner has already led to a series of types following still more closely the adaptability of the electric lamp. Burners have been produced to burn at an angle downwards, to burn horizontally, and even capable of being inverted at will, so as to burn either in the upward or downward position.

As eminent an author as Dr. Drehschmidt, of Berlin, commits himself enthusiastically to the advantages of this form of burner, as will be seen by a perusal of his recent paper on the subject, a translation of which appears in another section. Our London correspondent in the field of gas illumination, Mr. Chas. W. Hastings, Editor of the *Gas Engineers' Magazine,* London, also reports the continuous increase in popularity and use of the inverted burner and kindred forms of gas light.

The use of "intensified" burners, *i. e.,* of burners in which either gas or air is supplied at pressure above the normal, of which we have also previously spoken, are already a commercial factor in Europe, and are likely to become so in this country as well. We have information from a private source that an American inventor has developed successfully a process of mechanically mixing gas and air before it is supplied to the mains, and it is claimed that such a mixture burned in the best burners will give an efficiency of above 90 candles per cubic foot.

With the marked increase in efficiency resulting from the methods mentioned, and with the admittedly greater artistic possibilities of the inverted burner, it will readily be seen that gas is not at all likely to fall far behind its present position in the field of illumination, at least not so long as the generation of electricity requires

the use of fuel in engines of the present type. Should some inventor, however, discover the long sought means of securing an electric current directly from the potential energy of coal or other fuel, all predictions would have to be revised. But unless this occurs gas lighting is pretty sure to continue to hold its present position for many years to come.

IS THE SIXTEEN CANDLE-POWER STANDARD FOR ELECTRIC LAMPS OUT OF DATE?

The *Electric World* in a lengthy editorial contends strongly that the sixteen candle-power lamp as a standard unit is behind the times, and that it is bound to be superseded in the near future by higher units. Illuminating engineers, however, do not seem to be unanimous in accepting this view of the case. When the matter was mentioned at the recent meeting of the Illuminating Engineering Society, President Marks emphatically placed himself on record as opposed to the idea; and although no further discussion of the matter followed, it was apparent that there was much sympathy with his position among the members present.

That there is a general tendency toward the using of higher units is plainly evident from the facts. So far as there is genuine competition between gas and electric light, the contest is usually to see who can produce the greatest flood of light for a given expenditure, entirely regardless of the visual and æsthetic qualities of the illumination produced. The incandescent gas burner, with its fairly dazzling light of 60 rated candle-power, or more, could only be beaten by a cluster of the standard sixteen candle-power electric lamps, or the electrical arc. To compete with the latter the "gas arc" was produced, which was simply a cluster of incandescent mantles. At last accounts electric lighting had scored a complete victory by the introduction of the flame arc, which has left the gas arc and all other forms of illumination hopelessly behind in the race for garish brilliancy.

In many respects the contest reminds one of the country band tournament, in which the band that made the most noise won the prize. Increase in light power by closely clustering small light units has usually and rightfully been condemned by illuminating engineers; and the most serious fault of the arc lamp has been its necessarily high light-power as well as high intrinsic brilliancy.

As to the value of illuminating engineering, the editorial referred to says: "In fact, the conditions are such that illuminating engineering is becoming an important part, not so much because of what its practitioners can accomplish with respect to the design of illumination along ideal lines, as in getting the best results with conditions everywhere conflicting with the ideal." In one sense this view is a true one. The value of the illuminating engineer at the present time, and possibly for sometime to come, will be largely measured by his present ability and ingenuity in correcting the outrageous blunders that have been made in laying out illuminating systems heretofore. "Conditions conflicting with the ideal" is truly a very mild way of describing them. They more generally conflict with common sense, with the most obvious principles of illumination, and with the accepted canons of artistic taste; and the illuminating engineer who can bring a semblance of order out of this chaos is worthy of due praise,—as well as his fee.

But in that department of work which deals with the planning of new installations there is no more reason for "conditions conflicting with the ideal" hampering or restricting the free play of his judgment and skill than there is for their interfering with the plans of the architect or electrical engineer. Outlets properly located are not usually any more expensive than those located by guess; in fact, the contrary is rather the case. Good

illuminating engineering will ordinarily reduce wiring cost, but it is one of the anomalies of the general lavishness with which buildings are constructed in this country that a few dollars difference in original cost in the lighting installation is allowed to seriously reduce the efficiency of the illumination produced, and so produce an operative tax continuing as long as the installation is in use.

There are usually several ways of producing practically equally good illuminating results, and the illuminating engineer must be sufficiently conversant with wiring principles and pipe fitting to select the one which can be installed at least expense; but, to knowingly reduce the efficiency of the illumination in order to make what can at best only be a trifling reduction in the cost of installation is simply a case of "saving at the spigot and wasting at the bung."

There are undoubtedly many cases where multiple lights, either in clusters or in chandeliers, can be very advantageously replaced with the more efficient units that are coming into use, but the ordinary dwelling house certainly does not afford such a case. While the general race of each to outshine his neighbor is interesting along "the Great White Way," there are few who wish to carry the contest into their private apartments; the rest and eye comfort resulting from a soft and comparatively low intensity of illumination are still demanded for the home. The chandelier with multiple lights, or the cluster, has the advantage of affording a variable illumination, and on this account alone must always take precedence over the single unit of high power for private lighting.

"The craving for brighter artificial illumination" may not yet be satisfied, it is true, but if the only effect of the more efficient lamps which are making their appearance is to result in nothing more than a stimulation of this craving, their advent will be of very questionable advantage to the cause of good illumination. In one point at least their use is a distinct menace to the best illuminating effects, viz.: their excessive intrinsic brilliancy; and it will be within the province of the illuminating engineer to see that this defect is counteracted by the use of proper methods of diffusion, and that the excessive general brilliancy is not produced simply because it can be at no greater outlay of money. If there is one principle in the confessedly imperfect science of illuminating engineering that is generally accepted, it is that the tendency to excessive brilliancy is a more common fault at the present time than insufficient light, and that a better distribution and more complete diffusion of the light used are the two improvements most often demanded. Neither of these reforms can be furthered by discarding the present 16 candle-power standard in favor of high power units.

THE ILLUMINATING ENGINEER AS A MUNICIPAL OFFICER

In our last issue we called attention to the necessity of the addition of an illuminating engineer to the list of city officials in order to insure the best lighting service, whether the same is furnished by a private corporation or a municipal plant.

On the subject of the value of such an office, and the necessary compensation of the engineer, the *Municipal Journal* has the following very logical remarks:

"When most city positions were elective the honor of receiving them was the chief reward, and the matter of salaries was not an urgent one. But there is no particular honor attached to the position of Superintendent of Lighting, or even City Engineer, and the salaries must offer sufficient attraction in themselves to obtain the desired ability. Moreover, the ability, or lack of it, in a City Engineer has been difficult to prove so far as it was expressed in economy of expenditure; and hence the low salaries commonly paid such officials. But a lighting superintendent is inevitably compared as to results with the head of a rival plant in the same city, or a similar plant in a neighboring city, and his efficiency is computable. If he is a valuable man, private plants stand ready to pay him his worth, and to retain him the city must pay the same."

Correspondence

FROM OUR LONDON CORRESPONDENT

THE INVERTED GAS BUURNER

This month we may be pardoned if we devote the best part of an article to a description of some of the new systems of illumination, and particularly Inverted Incandescent Burners. No system of gas illumination has so quickly come to the front, and certainly in the history of gas lighting no burner has been so popular with the public. The soft balls of light, shedding golden luster from many points, are a great improvement upon heavy three or five light chandeliers hung in the center of the room. Flaring gas flames from fish-tail burners, unregulated, and hidden by heavy frosted or semi-opaque globes, with the flame illy supplied with air, gas partly consumed, giving off, too often, visible clouds of carbon, such was the illumination of our houses a quarter of a century back. But now consumption of gas has been immensely decreased, and by the use of scientifically constructed burners, and the incandescent mantle, an increase of illuminating power which has surprised every one has been obtained. Attention is now being paid to simplicity of fittings, and the inverted burner has brought gas illumination up to—if not beyond—the artistic capabilities of the electric glow lamp, with a larger and cheaper life per lamp and a lower cost per unit of light.

With the introduction of compressors for air and gas the duty per cubic foot of gas will be greatly increased; all that is needed is an apparatus which is automatic in its working and inexpensive, which can be fixed in any private house.

In a recent article reference was made to an apparatus, the invention of Mr. Scott-Snell, for compressing gas and air. We illustrated the apparatus, which is mainly intended for use when burning gas under pressure, in conjunction with incandescent mantles. The arrangement consists of a cylinder in which the air or gas is compressed by means of a reciprocating piston, provided with cupped leathers. In a line with the cylinder is placed a water cylinder containing a piston fitted with a cup leather; the pistons are connected directly together by a spindle which passes through stuffing boxes in the respective cylinder covers. The admission of water to the cylinder is controlled by a circular balanced-valve, thrown alternately to one end or the other, of its casing, causing it to alternately exhaust and admit water to the upper side of the water-actuated piston; the water always having free access to the underside of the piston.

The main water valve is controlled by a subsidiary or miniature circular balanced-valve, which works through the center of the main valve, and by alternately exhausting and filling a cylindrical chamber at the head of the valve causing the main valve to move in either directions in perfect coincidence with the small valve, which valve projects through the lower end of the valve casing, and is actuated by a tappet arm projecting from the rod or spindle connecting the two pistons. This compressor is automatic, requiring only a supply of water which may be taken from the ordinary water service. The illustration describes more fully the working parts of the apparatus, which is now perfected and has become an article of commerce. It weighs about 15 lbs., and the space occupied, including the air-reservoir, is 3 ft. by 1 ft. The machine illustrated produces 4,500 candle-power for a consumption of 113 cubic feet per hour, which is equivalent to a reduction in price of about fifty per cent. The compressed air is delivered in a separate pipe to the burner, and a constant pressure is automatically maintained by the

adjustable governor. The air mixes with the gas at the burner, which is fitted with a combination gas and air nipple, the gas being used at its normal pressure, the gas and air have separate circuits and are under separate control. It is easy to regulate the air supply to exactly suit the requirements of combustion, and so insure the highest attainable efficiency. The correct volume of the mixture can be con-

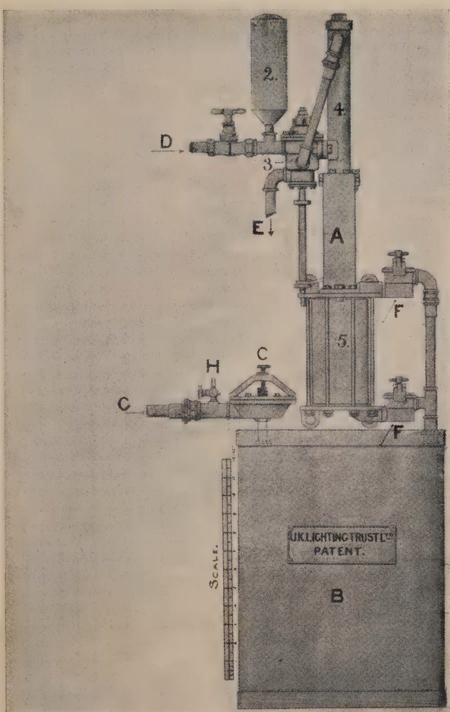


FIG. I.—DETAILS OF AUTOMATIC COMPRESSOR.

trolled and the supply determined to suit any particular size of mantle.

Any existing gas lamp can be used with the system. Examples are shown of a cheap form of single-unit-lamp suitable for factories, workshops, etc., where the light is required to be thrown downwards, and a street lamp for public lighting with clustered burners; the system can, of course, be applied to all kinds of house fittings, inside and outside store lamps, billiard table pendants, etc. By the use of the machine described the compression of air becomes an easy matter, and the burning of gas and air at a high pressure, within the possibilities of the private consumer on either a large or small scale.

Inverted incandescent burners are now being used almost universally, both for ordinary domestic lighting, and also in the high power lamps, which are so popular. The downward light, assisted by reflectors, gives such a very useful duty that the demand is extending very rapidly. O this type is the "Vesta"; in this lamp each burner is provided with an inner glass chimney, which, in addition to protecting the mantle, also promotes more perfect combustion and gives intensity to the incandescence of the mantle. Metal tubes are placed above these glasses and tend to increase the rapid flow of warm air, and so disperse the heated products of combustion. We are told that the tested efficiency of these lamps is 31 candles per cubic foot of gas consumed; each number consumes four cubic feet per hour.

It was to be expected that combinations of inverted gas burners would be attempted; many of these we have seen but the latest novelty is a special fitting to carry "Inc." mantles, produced by Messrs. Norden & Co., and which we illustrate. The burner is made simply, in dual form, or in clusters. The fitting can be used to convert the ordinary standard or pendant for cluster lighting. The burner, it may be mentioned, is made in four parts, the mantles are easily adjusted, and no visible metal parts are exposed to the flame. These burners with opal or tinted globes give most effective lighting, the light being softened, and yet more illuminating than the electric glow lamp.

The new methods of fitting inverted burners to existing gas fittings are being brought out every day; we illustrate several. The first is the invention of Mr. O. Wiederhold, of Jersey City, N. J. In this fitting an annular space is left between the burner switch

coupling and pneumatic valve in the up and down positions. The former is shown in dotted lines. The valve may be used with an ordinary C Kern burner.

It is claimed for Mellphin's adapter that it insures a perfect ball of white light with a consumption of 2½ cubic feet per hour.

Another adapter, the Godfrey, is manufactured in Scotland; it appears to be a very simple and inexpensive fitting, sliding over the Bensen tube.

The most perfect and best adapter is the invention of Messrs. Joyce, Bray & Co., of Leeds; it is reversible, and can be used alike upon upright gas fittings or brackets as shown. These new reversible burners are now fitted with the pneumatic distance lighters. With the Bray Reversible Inverted Burner, a lighting efficiency of 25 candles per cubic foot of gas can be obtained. The burner is efficient at pressures ranging from 10 tenths to 40 tenths. The globe is held in position by screws fixed in a patent spring holder; so that the globe can be removed without removing the screws for cleaning or for renewing the mantle.

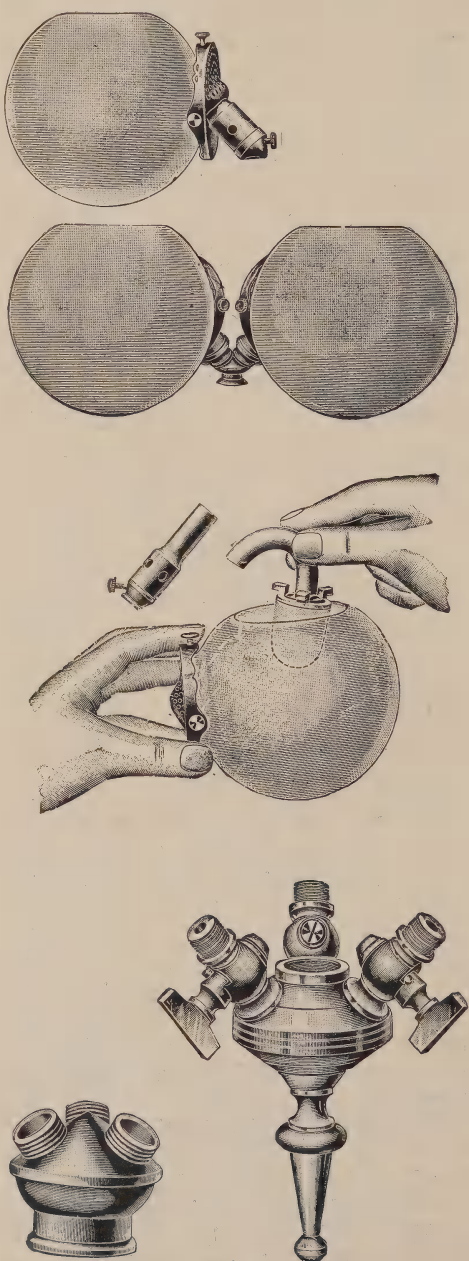


FIG. 2.—LANCASTER BURNERS.

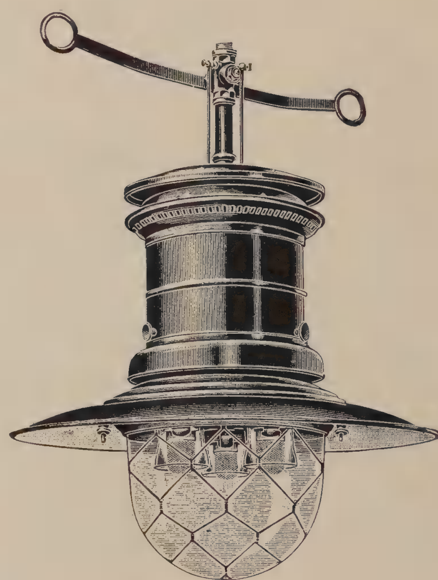


FIG. 3.—VESTA INVERTED GAS LAMP.

Lamp pendants have been in use for some time, hung by flexible tubes which, by means of a spring, can be drawn down close to the table or left

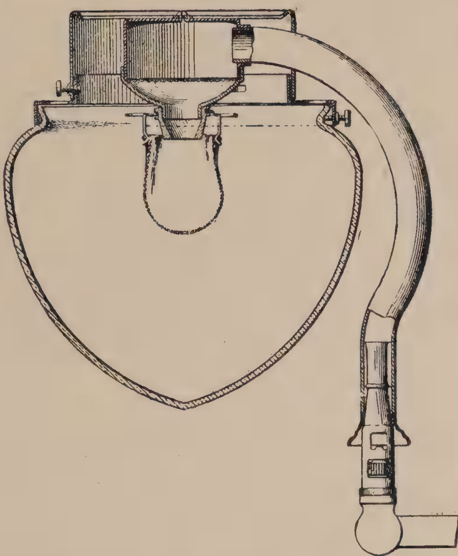


FIG. 4.—WIEDERHOLD'S BURNER.

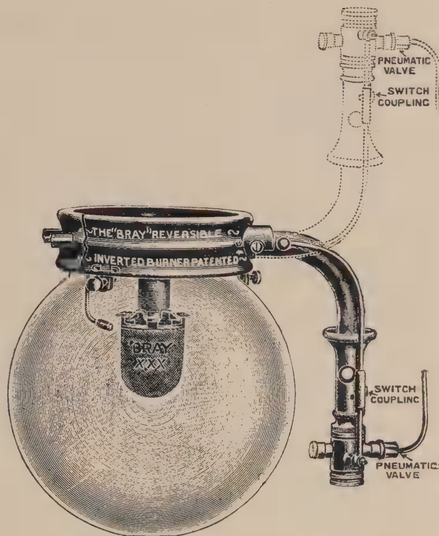


FIG. 7.—BRAY REVERSIBLE BURNER.

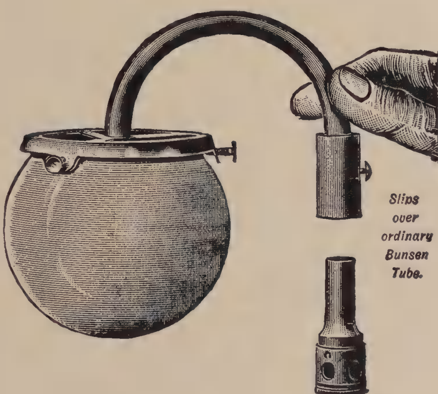


FIG. 5.—GODFREY BURNER.

FIG. 8.—MELLPHIN'S ADAPTER.

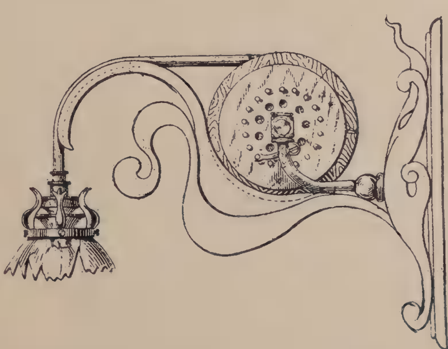


FIG. 6.—HANWELL'S WALL-BRACKET.

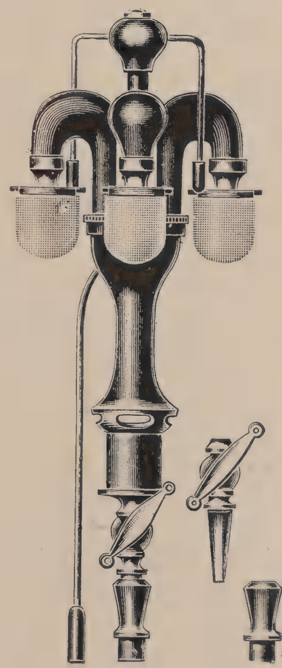


FIG. 9.—COWAN UPRIGHT INVERTED BURNER.

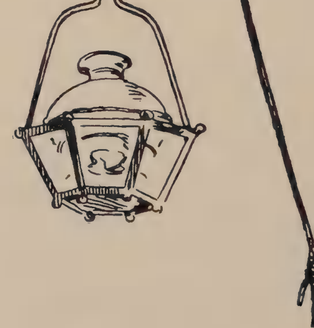
at the ordinary pendant height. The same principle has now been adapted to wall brackets. In these the friction member is held stationary by a pawl and ratchet mechanism, whilst the fitting is drawn down, but rotates with the drum upon which the slack of the cord or tube is wound when the fitting is raised. The pawl is stationary, and the ratchet is carried by the friction member, so that the ratchet overcomes the pawl during the return movement of the drum. The action of the Hanwell light is shown in the illustration.

Another, and quite a novel claimant for public favor is the Lancaster burner. It has been designed to utilize a cluster, say of six mantles all rendered incandescent by jets of flame issuing from the tops of a Bunsen burner, the mantles resting upon steatite stalks, which project from the head of the burner, placed at such an angle as to insure the light being thrown downwards, the angle ranging from 30 to 45 degrees, and by means of a glass shade to subdue the light, concentrate it and eliminate all shadow on either ceiling or floor. The burner is provided with a special regulating nipple in order to adjust it for varying pressures. The light can be regulated to any size, deposits no soot on the mantles, the combustion is perfect, and the clustered light most effective. We have before us one of these "Lancaster" lights. They may be used with or without a shade and are easily adapted to any ordinary gas fitting, or they are quite as suitable for fixing in ordinary street lamps, provided they are windproof. A cluster of six mantles will give a soft light and illuminate a room 20 feet square.

We cannot include these notices of new illumination methods and fixtures without reference to Cowan Upright Inverted Gas Burner. The burner is made entirely of cast brass and any of the well known inverted mantles may be used with it; the nozzles are made to "socket" on or off, so that each burner can be readily lifted off for the renewal of mantles, etc. In these burners the air and gas flow naturally in the mixing chamber; they do not depend entirely—as do most Inverted Burners,—on the potential energy to overcome the natural tendency of the air and gas to rise; with their use is far less possibility for the gas, or gas mixed with air to pass, burn with a luminous tip, deposit carbon or give a flickering light. Each cluster is fitted with an adjustable regulation; they can be adapted to any form of lamp for indoor or outdoor illumination; the burners are fitted with Pilve light and Plug's Socket to lift on or off supply pipe or fitting.

It is but a step from the sublime to the ridiuclous; so far as gas illumination goes, we have described several forms of gas burners and fittings which will give sublime effects, and we reproduce a sketch of light of other days which we might take to represent "The illumination ridiculous." The original of this ancient lantern hangs in the historic mansion of La Malmaison, in the Court of Honan; such were the lanterns which illuminated the streets of gay Paris in the time of the great French revolution, something more than a hundred years ago.

CHARLES W. HASTINGS.



"THE LIGHT OF OTHER DAYS."

FROM OUR READERS

Editor THE ILLUMINATING ENGINEER.

DEAR SIR:—I hope you will be able to find room in your columns for a few remarks on the—to me—inexplicable claims on behalf of the penetrative powers of the Mercury vapor light, attributed to Dr. Steinmetz on p. 545 of your September issue.

Any luminous object looks approximately equally bright at all moderate distances, and for the following reason. The total amount of light entering the eye, and the area of the image formed on the retina are both inversely proportional to the square of the distance of that object.

It does not appear *exactly* as bright for two reasons. (1) Because some of the light is absorbed in the atmosphere on its way to the eye, (2) Because all parts of the retina are not equally sensitive to light.

Now, it is generally agreed both on scientific grounds and as a result of practical experience that luminous waves of great wave length penetrate the atmosphere best. I have not been able to find any published figures for luminous waves, and I am aware that Mr. Orme Bastian has recently maintained the contrary opinion.

Nevertheless it may fairly be said that the evidence in favor of the fact referred to is overwhelming. Also it is well known that the "yellow spot," the central portion of the retina is more sensitive to red light and less sensitive to green and blue light than the surrounding portion and by experiments (some of which are described in THE ILLUMINATING ENGINEER for September), confirm this. Consequently, a red object tends to appear redder and a green object darker as we move away from it.

Both these effects are unfavorable to the Mercury light. I do not dispute that if the c.p. of a Mercury light is compared against a white standard at various distances, the c.p. tends to work out brighter as the distance from the photometer increases. But this is because the illumination of the photometer disk becomes weaker and weaker until eventually the Purkinje effect begins.

But, as I have shown, the objective brightness of the retina image, instead of decreasing according to the inverse square law, must (except for atmospheric absorption) remain constant, and by the time atmospheric absorption has decreased the illumination sufficiently to allow the Purkinje effect to begin, the image falls entirely within the yellow spot, where there are no rods but only cones and where the Purkinje effect is comparatively weak.

Probably also the atmosphere has by then filtered out all but the red rays.

This, at all events, explains what is common experience, namely, that all lights commonly appear orange or even red in the distance. My slight experience of the Mercury lamp tempts me to suppose that its striking color attracts the eye and so produces an impression that it can be seen from a distance, when other lamps cannot.

If, however, the light is really more easily visible at a distance than ordinary lights, it seems to me very difficult to account for the fact on physiological grounds.

I am, yours truly,
J. S. DOW.

Mayfield,
Shepard's Hill,
London.
Oct. 11, 1906.

The Illuminating Engineering Society

PAPERS PRESENTED AT THE REGULAR MEETING HELD IN NEW YORK CITY, OCTOBER 22

APPLICATION OF PHOTOMETRIC DATA TO INDOOR ILLUMINATION

By Ernest C. White, Member.

(Slightly abridged.)

INTRODUCTION.

The opinion has been frequently expressed in the discussions before the society that the most important branch of illuminating engineering work lies in the application of photometric curves of lamps and their accessories to the requirements of practical illumination. Probably most of us who have endeavored to practice this belief, not only for publication, but in the calculation of every day lighting problems, have found the ordinary polar diagram and the law of inverse squares a very clumsy set of instruments for rapid work, and, on the other hand, have concluded that "judgment," i. e., observant guesswork based on the shape of these same polar diagrams—is liable to mislead in regard to results.

Now, there are two ways in which distribution curves are pre-eminently useful: First, in comparing the results obtained with different lamps and accessories; and second, to provide a basis of calculation for the proper location of lights when the lamps and accessories have been determined upon. For the first of these uses the polar photometric curves are misleading in so far as they are popular, i. e., in so far as they may be used by persons not appreciating the actual phenomena which they represent. For the use of illuminating engineers, however, this misleading quality has doubtless been exaggerated. The Rousseau diagram is equally useful in reference to the character of distribution, and far more valuable for purposes of absolute comparison between different illuminants or different accessories. But all this has very little to do with the *application* of this data to the needs of every day work.

CURVES OF UNIFORM ILLUMINATION.

I have already described in *The Illuminating Engineer* for July, 1906, the theory of curves of uniform illumination, which are, so far as I know, the simplest device for graphical calculation yet provided for the application of distribution data to the design of illumination. You will doubtless note, without need of my referring to it, the typographical error in that article, as the first equation stated should of course, be $d = \sqrt{\frac{C}{L}}$

These curves of uniform illumination are simply polar diagrams representing the distances in all directions at which equal illumination is produced by the source for which the curve is plotted. Marginal scales are provided which read in feet, without subdivision for various intensities of illumination. For convenience these scales are laid off so that that radial distance between every tenth circle equals 1 foot for unit illumination, i. e., 1 foot-candle. For more powerful sources it is necessary to plot the curves to one-half, one-fifth or one-tenth of this scale, as the case may be; in which case of course one division in the 1 foot. The actual scale used for plotting scales represents 2, 5, or 10 feet instead of is noted in each case on the upper left hand margin.

Fig. 1 represents the uniform illumination from a 32-cp. incandescent lamp with a pagoda reflector, while Fig. 2 is the ordinary distribution curve for the same source. Fig. 3 represents uniform illumination and distribution respectively from a 16-cp. incandescent lamp, fitted with a pagoda reflector giving broader distribution. These curves have been selected from my data book without special reference to the distribution characteristics, except that the first two curves will be utilized for a more extended illustration.

Referring to the curves, it will be noticed that each of the various scales is labeled in foot-candles, i. e., each scale applies correctly to the curve for the intensity of illumination marked above it. Thus, in Fig. 1 the illumination directly below the lamp

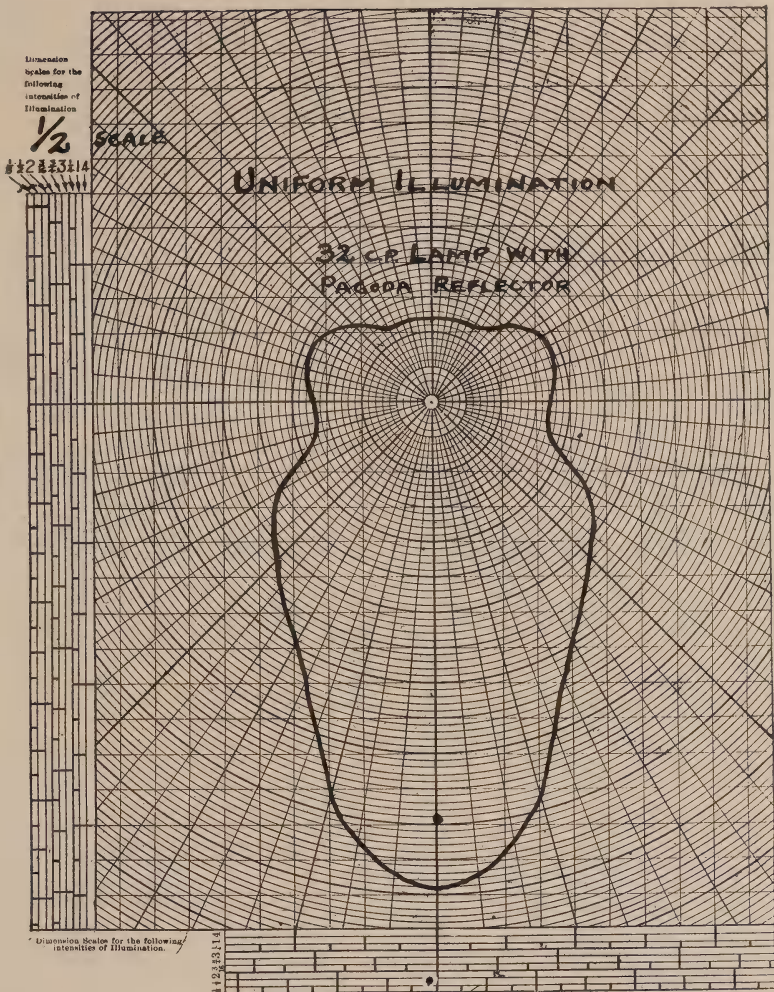


FIG. I.—CURVE OF UNIFORM ILLUMINATION OF 35 CP. LAMP WITH PAGODA REFLECTOR.

will be 1 foot-candle at 15 feet distance (i. e., seven divisions on the 1 foot-candle scale equals 15 feet, the curve being plotted to ½ scale); 4-foot-candles at 7 feet distance; ½-foot-candle at 16 feet distance; 2-foot-candles at 10 feet distance; ⅛foot-candle at 40 feet distance, ect., etc. In order to calculate illumination at an angle of 45° from the vertical, the radius of intersection is swung around to a line parallel to the scales, the reading then being 0.5 foot-candle at 9 feet distance, etc., if the rays are incident to the plane to be illuminated. If the plane in this case were horizontal, the horizontal and vertical rulings (provided on the co-ordinate paper to facilitate reference to the scales) easily permit of swinging a radius proportionate to 0.5 foot-candles illumination through the angle of incidence and thus reading with close approximation the actual illumination, which would be about .35 foot-candle at 9 feet distance.

It is the object of this paper to advocate the use of curves of uniform illumination. The possibilities of graphical calculation from these curves and the scales provided, will appeal to you in connection with all problems involving the law of inverse squares. The method of reading from these curves does not need further explanation, but I wish to call your attention to

several advantages offered for purposes of quick comparison or selection of various means of illumination.

1. The shape of the curve represents the *effect* produced, and not merely the cause which is the case with the ordinary polar distribution curve.

2 The area of the curve is not largely affected by the character of distribution as in the polar distribution curve.

3 These curves afford instant reference to the best location for lights; i. e. proportion of distance from ceilings and from floors; the best angles for bracket lights, etc., and where placed within glazed fixtures, such as described further on the shape of the curve is of accurate assistance in determining the shape of the art glass to be lighted up.

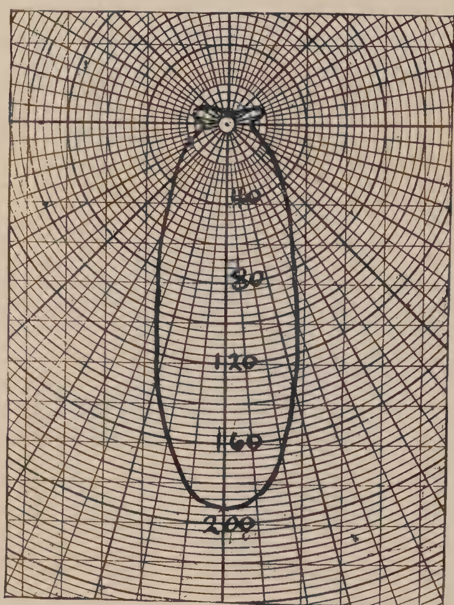


FIG. 2.—DISTRIBUTION CURVE OF 16 CP. LAMP IN PAGODA REFLECTOR.

APPLICATION TO FIXTURE DESIGN.

We have had a great many examples of calculation for illumination of rooms large and small, so I will further illustrate the convenience of uniform illumination curves by a problem of slightly different character, viz., the design of a single fixture for the more expensive residence work. This is a class of fixture wherein the most lavish taste is too often combined with neglect of the principals of illumination, with the result of producing lighting furniture somewhat extravagant from point of usefulness.

The fixture described is a dining-room chandelier. The room is 16 x 22 feet with 11-foot ceiling; plate rail, 7 feet 9 inches high; ivory-tinted plaster ceiling; very dark frieze, and dado in light plaster panels. The lighting scheme includes wall brackets, which are placed near the ends of the room, so for the purposes to be served by this particular fixture we will consider the room 16 feet square.

The requirements are to produce fairly brilliant lighting without any glare in the eyes of persons seated around the table, and to provide indirect lighting from the same fixture for the general illumination of the room. The reflector for which curve is shown in Fig. 3 was chosen for the table lighting, and this is used with a 32-cp lamp. This is covered with an art glass shade hung low enough to intercept the direct rays at a point below the eyes of the diners, the bottom of the shade being placed 6 feet above the floor. This is somewhat higher than usual, and was particularly desired by the owner. As the reflector used is of generous proportions, it may be assumed that there will be small error in doubling the illumination represented in the curve Fig. 3 for a 16-cp. lamp. The distances from the lamp to surface of table are indicated in Fig. 4, which is a partial cross section of the room. Referring again to the curve, it is easily calculated that the illumination at 3 feet 10 inches distance 0° is about midway between 2 and 3 foot-candles with 16-cp lamp, or 5-foot-candles for a 32-cp lamp. At 4 feet and 15° the illumination is seen to be about 1.7 foot-candles multiplied by Cos 15° and doubled for a 32-cp lamp, which equals 3.3 foot-candles. In like manner the illumination at 4 feet 6 inches and 30° is found to be 2.65 foot-candles. Observe that in arriving at these values absolutely no computation is required, other than reference to the curve and scales.

The upper part of the fixture is a basket to conceal 6 32-cp lamps pointed at an angle of 30° from the horizontal, and equipped with the reflector for which curve is given

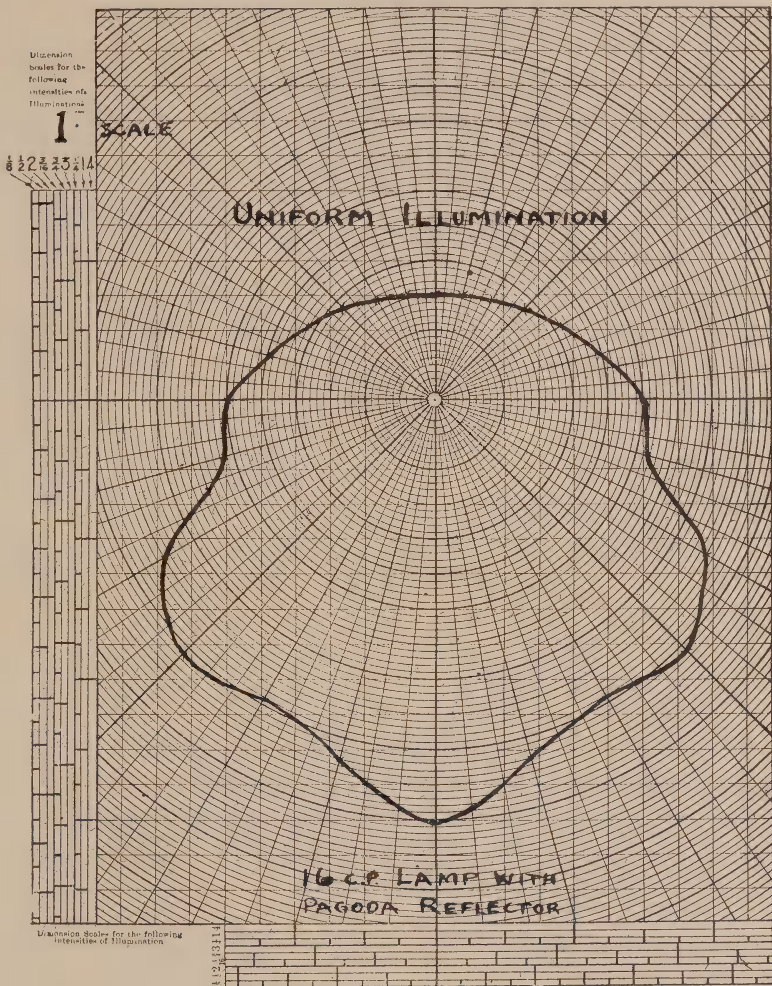


FIG. 3.—CURVE OF UNIFORM DISTRIBUTION OF 16 CP. LAMP IN PAGODA REFLECTOR.

in Fig. 1. Fig. 4 gives the distances to ceiling and frieze at the various angles. I think anyone having taken a few moments to familiarize himself with these curves of uniform illumination will find no difficulty in arriving, by reference to this curve only, at solutions in accordance with the accompanying table:

While not as simple to describe, the same process applied to the other lamps of the group will afford an easy summation of illuminating effects which, of course, increase the illumination near the center to an approximate uniformity. The falling off in intensity on the ceiling near the side wall is desirable in order to avoid undue con-

Angle from Nadir.	Distance.	Angle of Incidence.	Illumination.
60°	3 feet 6 inches	0°	2.0 foot-candles
45°	3 feet 8 inches	15°	3.4 "
30°	4 feet 1 inch	30°	4.7 "
15°	5 feet 0 inch	45°	3.8 "
0°	7 feet 0 inch	60°	2.0 "
5°	8 feet 6 inches	25°	2.6 "
15°	7 feet 6 inches	15°	2.9 "
22°	7 feet 4 inches	8°	1.5 "

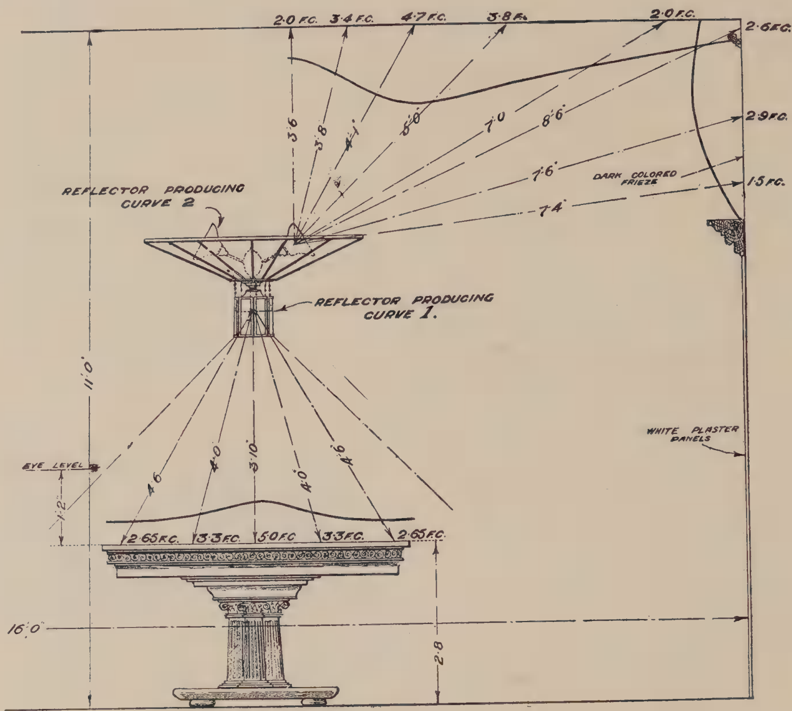


FIG. 4.—APPLICATION OF THE METHOD TO FIXTURE DESIGN.

trast with the dark colored frieze, which receives the rays at a smaller angle of incidence, thus producing a most harmonious effect with the lighting from this direction. The sides of the basket are high enough to conceal the reflectors when viewed from a point 11 feet from the center of the room and 5 feet 6 inches from the floor.

Lest it should appear that this catering to the requirements of illuminating engineering has led us into proportions impossible to use from an artistic standpoint, I append a sketch, Fig. 5, of the finished fixture used. This has about 5 feet drop over all, and 42 inches spread. The 6-piece shade suspended around the table light is 8 inches high by 8½ inches in diameter. When two or three hundred dollars is expended on a fixture of this kind, it is evident that the amount of work put into a careful calculation of lighting effects by the use of uniform illumination curves is far from extravagant.

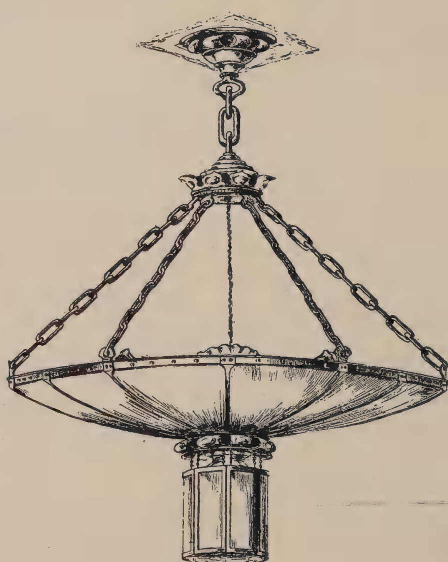


FIG. 5.—FIXTURE DESIGNED ACCORDING TO THE METHOD.

DATA ON INDOOR ILLUMINATION

By Mr. J. E. Woodwell, Member.

Illumination has been well termed an art rather than an exact science. Illuminating engineering, having for its basis the physical laws of light which are subject to rigorous mathematical demonstration and calculation, depends, nevertheless, upon many other important factors which tend to modify the application of fundamental principles and formulæ. In general, it involves a study of the character, color and intensity of artificial illumination; the type, number and position of radiants or light sources; kind of accessories; and, finally, the resultant optical, physiological and æsthetic effects. The object of this paper is to outline the methods commonly employed by the illuminating engineer in dealing with practical problems relating to indoor illumination, and to present examples illustrative of some of the principles involved.

In approaching a problem on illumination, consideration is first given to the quantity required. This will vary in accordance with the uses to which the spaces to be illumined are to be put. It has been found, moreover, that the eye adjusts itself over a considerable range in intensity, so that between certain maximum and minimum values the artificial lighting is equally effective. The final criterion of satisfactory illumination is, therefore, not a definite intensity as expressed in foot-candles, but a visual effect or physiological sensation incapable of quantitative expression. The primary fact to which we must refer is the light sensation and this is dependent upon the quantity of the light. Illumination has been defined as the light which in quantity and quality enables the outlines of objects to be discerned and colors to be perceived. It is evident, also, that the visual effect or apparent brilliancy is dependent upon the amount of light reflected from the object illuminated to the eye.

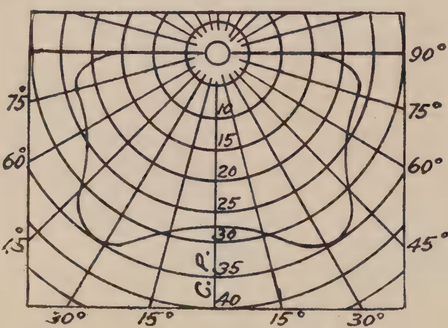
In consequence of the complex relation between the physical laws of light and the resulting physiological sensation, the quantitative measure of illumination is not to be wholly relied upon as the basis for calculation. Data taken from successful examples of indoor illumination where all of the conditions as to reflection values, etc., are known are most valuable, but, unfortunately, illuminometer tests made under such conditions that the errors to which such measurements are particularly subject are eliminated are very scarce. It is not out of place to direct attention to the present demand for a simple and practical illuminometer which shall be portable, accurate and low-priced. One practical illuminometer test will be described later in the paper, but in the absence of actual data similarly determined for almost every variety of indoor conditions, it is necessary to approximate general values for the intensity upon the basis of judgment and experience. It is known, for example, that 1 foot-candle is an amount which is sufficient to enable one to read print of this size type comfortably, while for newspaper print at least 2 foot-candles is desirable.

In the postal service, for reading addresses of mail in an endless variety of forms of pen, pencil and print with backgrounds of various color, a local illumination of from 2 to 4 foot-candles has been found by extended experience to be required; 2 foot-candles is generally sufficient for desk illumination, though for work involving much detail 3 and even 4 foot-candles has not been found excessive. For corridors, public spaces, assembly rooms, the figures range from .5 to 1.5 foot-candles, while in stores where dark goods are displayed or a brilliant effect is desired, 5 to 10 foot-candles is not uncommon. The latter amount is also required for tracing, drafting, engraving and other similar work. These intensities relate to the working plane, and in addition, consideration must be given to the walls and ceiling and whatever objects in the space are to be illuminated, and the figures determined upon for this purpose will depend principally upon the color and reflection values of such surfaces.

Having determined the intensity of illumination and its general distribution in a given space, it is necessary to choose the illuminant and its accessories for diffusing and directing the light, and to decide upon the number and position of units in order to secure the predetermined result. A discussion of the choice of illuminants will not be entered upon in this paper, but such

peculiarities or characteristics which may have a bearing upon their use will be noted.

In order to determine what may be accomplished with a given light source it is necessary to know its distribution curve, including that of any requisite accessory. Curves of practically all illuminants and many accessories have been widely published recently, and are available to the engineer.



FI. 1.—CURVE OF CANDLE-POWER DISTRIBUTION OF TANTALUM LAMP WITH REFLECTOR.

The distribution is generally shown on a polar diagram. Fig. 1, for example, shows such a curve for a Tantalum lamp with a prismatic reflector. Fig. 2 shows a similar curve for an unshaded 16-cp. electric lamp, and also the distribution obtained from the same lamp by two prismatic shades. Such curves are of great value to the illuminating engineer, but unless the underlying principles are kept well in mind, deductions from a comparison of such curves for lamps and reflectors of different types are apt to be misleading to the layman.

To illustrate this point, let *A*, Fig. 3, be a light source of the uniform intensity of 1 candle in all directions. Its curve of distribution in any given plane will obviously be shown by a circle, while the total flux of light from the source is represented by a sphere whose radius is 1 unit. Now if it is assumed that by means of a reflector the intensity throughout a zone generated by the arc *BC* subtended by the angle *BAC* of, say 15° below the horizontal plane is reduced one-half, the intensity over this area will remain one-half candle. If the flux of light borrowed from this zone is now redirected vertically downward within the same angle of 15°, then the average intensity of the zone generated by the revolution of the arc *DE* about the vertical axis will be increased to

$$1 + \frac{\tfrac{1}{2} \times \text{area of zone generated by arc } BC}{\text{area of zone generated by the arc } DE} = 4.83$$

as shown graphically in case II, Fig. 3, the ratio of the zones being approximately 1 to 7-2/3, as shown in case I, Fig. 3.

It is evident that a very small quantity of light borrowed at or near the horizontal may be made to enormously increase the intensity in the downward direction. The polar diagram which shows only the radial intensities does not, therefore, correctly indicate the change in flux of light at various angles. The prismatic shades giving the polar distribution as shown by curves 2 and 3, Fig. 2, for example, are of practically

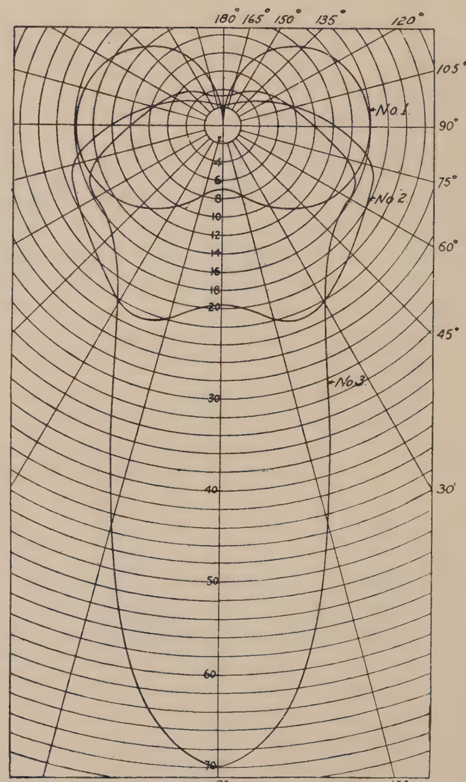


FIG. 2.—CURVES OF CANDLE-POWER DISTRIBUTION.

1. 16 c.p. bare lamp.
2. Same lamp with distributing reflector.
3. Same lamp with concentrating reflector.

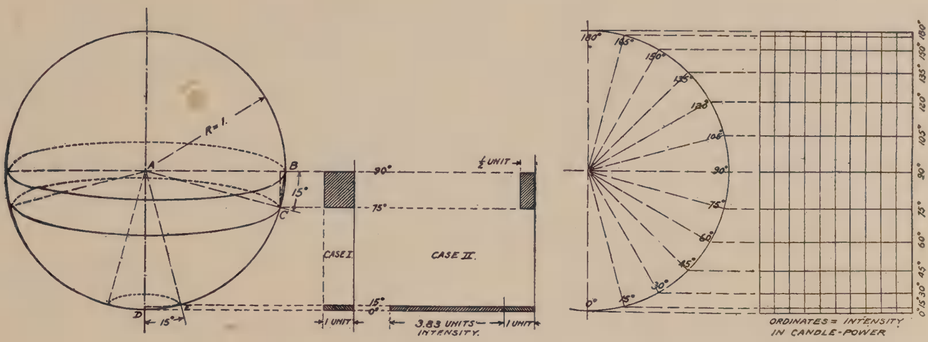


FIG. 3.—METHOD OF PLOTTING THE ROUSSEAU CURVE.

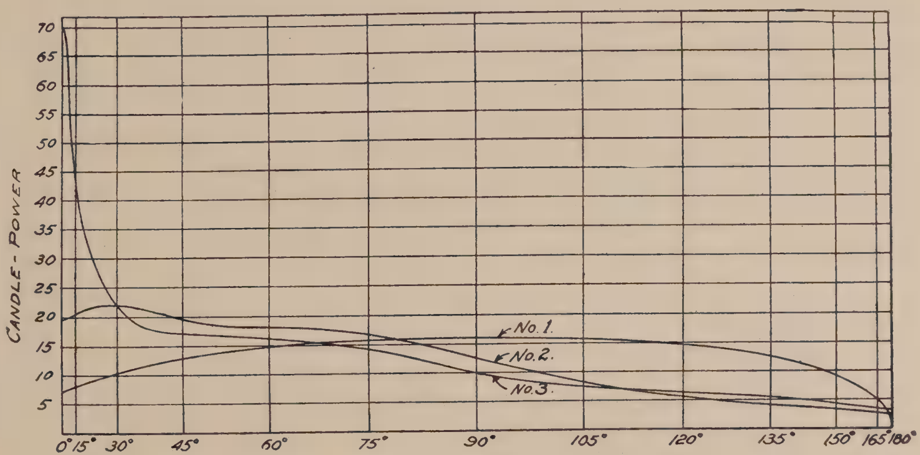


FIG. 4.—ROUSSEAU CURVES OF 16 CP. LAMP BARE, AND WITH REFLECTORS.

equal efficiency, but No. 2 appears to a decided disadvantage in the comparison. For general purposes, however, No. 2 would prove the most desirable and satisfactory reflector. To show this properly, resource must be had to the Rousseau diagram, which is constructed as shown in Figs. 3 and 4 on the theorem in solid geometry that the area of a zone is equal to its altitude multiplied by the circumference of a great circle. The surface of various zones, and consequently the illumination thereon, is thus proportioned to the respective altitudes, and if the altitudes of the zones included between the various angles are laid off by projection as shown in Fig. 4, and the candle-power at each radial line plotted thereon, the total illuminating power of a source of light will be proportional to the area inclosed by the Rousseau curve, and the flux of light through any zone will be correctly shown. The Rousseau diagram is essential to a proper comparison of the performance of various reflectors. Fig. 5 shows a Rousseau diagram of the bare 16-cp. oval anchored, carbon filament lamp, and the same lamp with the two prismatic reflectors which are comparable with the polar diagrams shown in Fig. 2. Here the volume or flux of light below the horizontal or between 0° and 90°, as represented by the area below the curve, is clearly shown to be about the same for reflector No. 2 as for reflector No. 1. The effect of both reflectors in redirecting the light of a bare incandescent lamp from the upper to the lower hemisphere is also clearly shown. The difference between the area below the curve of the reflector and that of the bare lamp

should properly show the absorption of light in the material of the reflector, and any other losses, this being a measure of the efficiency of the shade.*

Given the distribution of a light source, it is possible to determine the intensity of illumination produced at any point by the fundamental law of distances, which, on the assumption that the luminous source is practically a radiant point, states that the quantity of light falling on a given surface varies directly as the illuminating strength of the light source and inversely as the square of the distance from the source. In Fig. 6, if *O* represents a point source of light of candle-power CP, the intensity of illumination upon any plane at right angles to the rays of light, known as the normal illumination, may be denoted by I and is equal to $\frac{CP}{d^2}$ where d is the distance from the light source to the normal plane. If d is expressed in feet and CP is the candle-power of the source in the given direction, the formula $I_n = \frac{CP}{d^2}$ will give the illumination upon the normal plane in foot-candles. For points on a plane not normal to the incident light ray the angle at which the ray strikes the surface must be taken into account, and, in accordance with Lambert's law of the cosines, the intensity of normal illumination multiplied by the cosine of the angle of deviation of the path of light rays from the normal.[2] In Fig. 5, for example, the illumination in a horizontal plane *AB* denoted as I at distance D from the foot of the perpendicular dropped from the source is equal to $\frac{CP}{d^2} \cos \Phi$. To facilitate calculations it is convenient to substitute the value of *d* in terms of *h*, the height of the source above the plane illuminated, and since $d = \frac{h}{\cos \Phi}$, $d^2 = \frac{h}{\cos^2 \Phi}$ and the formula $I_h = \frac{CP}{d^2} \cos \Phi$ may be written $I_h = \frac{CP}{h^2} \cos^3 \Phi$. In the same way the vertical illumination is given by the formula

$$I_v = \frac{CP}{d} \sin \Phi, \text{ or } I_v = \frac{CP}{h^2} \sin \Phi \cos^2 \Phi .$$

Complete tables giving values of $\cos^3 \Phi$ for various angles have been published.[3] The following table shows the values for each five degrees:

Φ°	$\cos^3 \Phi$	Φ°	$\cos^3 \Phi$
1	1.000	40	.449
5	.988	45	.353
10	.955	50	.265
15	.901	55	.189
20	.829	60	.125
25	.744	65	.0754
30	.649	70	.0400
35	.550	75	.0173

To illustrate the application of the foregoing principles, Fig. 6 shows the method of obtaining the illumination curve of a single light source consisting of a tantalum lamp with prismatic shade giving the distribution curve shown in Fig. 1 and located 5 feet above the horizontal plane to be illuminated. The height of the lamp above the horizontal plane may be laid off to a convenient scale which will hold also for horizontal distances measured from the foot of the perpendicular dropped from the lamp. The illumination at any point in the horizontal plane may then be easily computed at the angles corresponding to regular intervals of horizontal distance. Since the distribution curve is derived by photometric measurement at regular angles, the

1. The Absorption of Light by Globes and the Action of Reflectors, "Photometrical Measurements," by Wilbur M. Stine.
2. Lambert, Photometria, 1760.

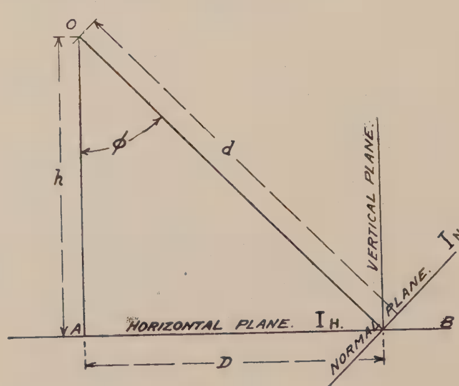
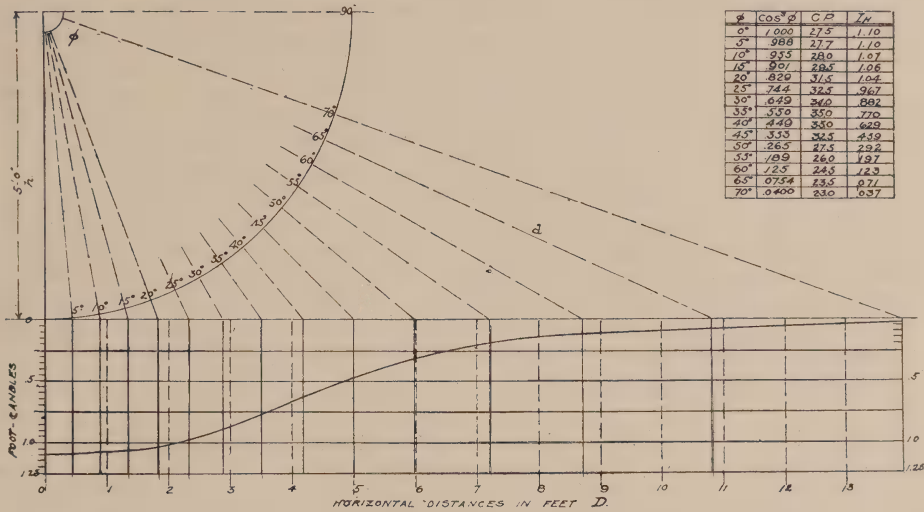


FIG. 5.

3. "Engineering of Illumination," by Van Rensselaer Lansingh; *Journal Western Society of Engineers*, Vol. VIII., No. 2.



ϕ	$\cos^3\phi$	C.P.	I_H
0°	1.000	27.5	1.10
5°	.988	27.7	1.10
10°	.955	28.0	1.07
15°	.901	28.5	1.06
20°	.829	31.5	1.04
25°	.744	32.5	.967
30°	.649	34.0	.882
35°	.550	35.0	.770
40°	.449	35.0	.629
45°	.353	32.5	.459
50°	.265	27.5	.292
55°	.189	26.0	.197
60°	.125	24.5	.123
65°	.0754	23.5	.071
70°	.0400	23.0	.037

FIG. 6.—CURVE OF ILLUMINATION OF TANTALUM LAMP WITH REFLECTOR.

calculation is facilitated by projecting the lines which form angles at five degrees intervals, which will be found to be close enough for practical work. Values for $\cos^3 \Phi$ may be taken directly from a table such as that previously given. Ordinates representing the foot-candles illumination at various points are laid off to a convenient scale, preferably $\frac{1}{100}$, and after a smooth curve is drawn through the points plotted, intermediate values for any given distance, as, for example, 10 feet from the foot of the perpendicular, may be obtained by interpolating on the curve.

After the illumination curve is obtained for a given light source at height h, values for any other height h′ may be obtained by multiplying the value of I at any desired distance d by $\left(\frac{h}{h'}\right)^2$. To obtain the resultant illumination at a given point in a horizontal plane produced by two or more light sources, the separate illuminations are added arithmetically.

In determining the illumination curve for a vertical plane representing a wall or a painting, values of $I = \frac{CP}{h^2} \sin \Phi \cos^2 \Phi$ are first calculated, thus giving the illumination at points on the wall in a vertical plane through the light source perpendicular to the wall. The illumination for points on the wall at either side of this plane is then computed by multiplying the values obtained by means of above formula by the cosine of the angle which the incident light rays make with the plane perpendicular to the wall. It is also necessary to take into account the obliquity of the light rays when the axis of the light source is not vertical, as, for instance, when the electric lamps on a chandelier are placed at an angle. When the illumination is produced from several sources the calculations become quite complex.[4] Moreover, the inverse square law does not hold for a number of light sources of appreciable size, such as the Moore tube, Cooper-Hewitt lamp, and the actual deviations are considerable even in the cases where large diffusing globes are used. The radiations from a cylindrical source have been investigated by Dr. E. P. Hyde, of the United States Bureau of Standards, in connection with the use of a Nernst glower as a light source in certain photometric tests showing the necessity in refined work of taking into account such errors as are likely to occur from a deviation from the law of inverse squares. The radiation from a cylinder of infinite length

4. The Distribution of Illumination in the Neighborhood of Two Lamps. J. R. Benton. *Electrical World,* May 5, 1906.

varies inversely as the distance from the axis of the cylinder, and in practice this law is approached in the application of the Moore tube. The Cooper-Hewitt lamp is far from a point source, but at distances long compared to the length of the tube its radiation approaches the law of inverse squares, while at comparatively short distances it is nearly proportional to the distance. Tests of the candle-power of the Cooper-Hewitt lamp on photometer bars of different lengths show variations of 46%.[5]

In the foregoing discussion no account has been taken of the effect of reflection. In practical work, the illumination received by a surface or object is frequently very materially increased by diffused reflection from walls and ceiling, the amount being dependent upon the distance of the light source from the reflecting surface and the coefficient of reflection. For interiors having dark walls or with large dimensions, the increase in illumination due to reflection is small, while under favorable conditions, such as small interiors with white plaster or painted walls and ceilings, or with white marble or similar interior finish, the direct illumination may be increased two or even three times. The theoretical constant is computed by the formula $K = \frac{1}{1\text{-}C}$ where C is given a value representing the actual coefficient of reflection of the walls or surfaces as the result of experiment or experience. For public buildings with relatively large interiors and light-tinted walls and ceilings, values of $\frac{1}{1\text{-}C}$ will be found to lie generally between 1.25 and 1.50.

In planning a system of illumination for a new building in which the color scheme for decoration has been determined, very small allowance can safely be made for reflection, particularly in the capacity of wiring circuits. Moreover, a certain margin is required in all calculations of illumination on a theoretical basis to allow for the inevitable loss in practice occasioned by the deterioration in candle-power of the light source. If, on the other hand, the economy is a sufficient object, and the finish of the walls and ceiling of a room of moderate dimensions is planned with reference to securing the full advantage of reflection the resultant illumination may by this means be more than doubled.

One more important factor remains to be considered—that of the intrinsic brilliancy of the light source. With the increase in efficiency accompanying the recent developments in arc and incandescent lighting has come a corresponding increase in intrinsic brilliancy, so that it is necessary either to shade such lights, or to keep them entirely out of the field of vision. The physiological effect of a light source of high intrinsic brilliancy within the field of vision is to so reduce the pupillary aperture that the normal sensibility of the eye is greatly impaired.[6]

In the table below the intrinsic brilliancy of a number of common light sources is shown in candle-power per square inch on the assumption of a uniform light intensity over the surfaces considered.

A test made at the Electrical Testing Laboratories using Lummer-Brodhun and Bunsen photometers and a 100-cp. standard incandescent lamp, mounted at the same distance from the photometer as the mercury vapor tube of type H with a luminous length of 21 inches, gave the following result:

5. London *Electrician*, July 20, 1906.

6. Some Physiological Factors in Illumination and Photometry. Dr. Louis Bell. Trans. Ill. Eng. Soc., June, 1906.

Moore tube	¼ to 1½	
Gas arc lamp	1 to 2	—alabaster globe.
Candle	3 to 4	
Cooper Hewitt lamp	3 to 6	—approximate.
Incandescent, frosted	2 to 8	—depending upon efficiency and style of bulb.
Kerosene oil lamp	3 to 8	
Mantle burner	20 to 25	—unshaded.
Acetylene flame	75 to 120	
Enclosed arc	100 to 200	—depending upon the globe used.
Incandescent lamp	100 to 300	—bare.
Nernst lamp	800 to 1000	—bare.

Distance.	Candle Power of Tube.
12 feet	178
8 "	169
4 "	164

While this test is not exhaustive, it serves to show that the candle-power emitted from the tube at distances over 4 feet from its center and along a line perpendicular to its length does not vary materially from the photometric law.

As a brilliancy in excess of five or six candle-power per square inch produces retinal fatigue and irritation, it will be seen that the most common illuminants require shades or enclosing globes if placed within the field of vision.[7] Even where illuminants of great brilliancy are located out of the field of vision, care must be taken to avoid regular reflection from objects to the eye, as light of comparatively low intensity entering the eye at an unusual angle is quite as detrimental as excessive brilliancy in the direct line of vision.

Two practical methods are available for reducing the injurious, direct and indirect, effects of an illuminant of great brilliancy. The light source or sources may be enclosed in an opal or ground glass globe of proper size to reduce the intrinsic brilliancy to a safe amount, or in the case of incandescent electric lamps the result may be accomplished by frosting and by the subdivision of the lighting units into those of small candle-power. The other method consists in placing the light source entirely out of range of direct vision and securing the desired illumination by diffuse reflection from a ceiling or cove. Both of these methods result in a loss of efficiency, but may be justified by an actual increase in effective illumination.

In applying the foregoing principles and factors in a given case it is necessary to fix the location of the light sources. In elaborately finished interiors the position is determined with reference to symmetry and architectural requirements. In such cases the efficiency of the system is not the prime consideration and is subordinated to the esthetic features. In certain offices and work rooms, on the other hand, where no architectural limitations are imposed, the problem may be solved with sole reference to securing the maximum illuminating result of the energy supplied. The subject may be best presented by reference to examples from actual practice in the lighting of public buildings.

7. Art of Illumination. Dr. Louis Bell, p. 307.

In the planning of the new Y. M. C. A. building, Washington, D. C., the illuminating requirements were first carefully studied and the position of fixture outlets and general type of fixtures and light sources including accessories determined. The wiring system was then planned to furnish the electric current in the right place, in the proper amount, and subject to the desired switch control. It would be needless to refer to this fact if this method, which is logically the proper one, were not so rarely followed in general architectural practice where the fixture outlets are established in location and capacity by precedent or a rule of thumb method which had its origin in the days of the gas chandelier. In such cases the fixture designer, as well as the illuminating engineer, if the latter is so unfortunate as to be compelled to cope with the additional limitations of fixed outlets, is subject to many needless restrictions. The third floor is devoted principally to educational work and includes a number of class rooms. This room is shown in plan and elevation in Fig. 7. As the room was designed for class room and lecture purposes, it was necessary to furnish adequate illumination for reading and writing in all parts of the room on a plane about 30 inches from the floor. Between 2 and 3 foot-candles illumination was decided upon as necessary, and on account of the blackboards located on one side of the room and the uncertainty of the color value of the remainder of the wall, it was decided not to make any allowance for reflection. A number of light sources were chosen in order to prevent shadows and to secure a fairly uniform illumination over the entire working area.

The natural selection of outlets for such a room according to conventional methods would be the two central outlets on the major axis of the room. This method, however, would not result in securing a uniform illumination on the working plane, and in order to bring up the results to the proper amount at the most distant points in the room, an excess illumination would

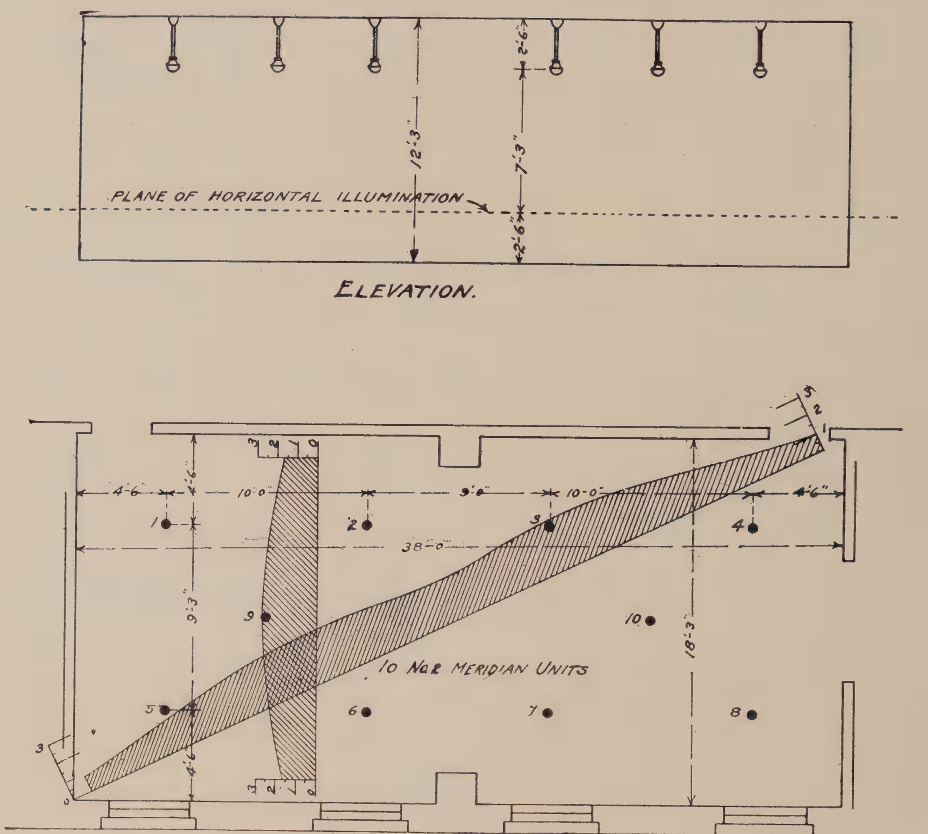


FIG. 7.—THIRD FLOOR PLAN, Y. M. C. A. BUILDING, WASHINGTON, D. C.

be furnished under the light source. A large number of light sources would result in exceeding the minimum illumination at fewer points, and would therefore be more economical, since by this means the aggregate candle-power could be reduced. The inverse square law also applies here, as with a larger number of light sources the average distance of the source to the point illuminated is less. The arrangement of outlets shown in Fig. 7 was finally selected as the result of preliminary calculation. The actual location of the outlets as shown on the plans are slightly shifted from the theoretical requirements to make the arrangement symmetrical in the room; also in consideration of a possible future division of the room by a partition in the center.

The light source which was selected as giving a satisfactory distribution was the Meridian lamp with frosted globe and prismatic reflector. By trial calculation the No. 2 unit was chosen, and its height from the ceiling made the minimum consistent with the required illumination on the working plane. The height of the lamp from the floor was thus made 9 feet 9 inches, a height which also places the light source practically out of the ordinary line of vision, with the arrangement of chairs and desks as shown in the photograph of the room, Fig. 8. The results of calculations based upon the sum of the partial illuminations from the 10 Meridian lamps are shown by the illumination curves in Fig. 7, taken on a diagonal and one transverse section. In the interests of temporary economy in lighting service the No. 1 Meridian unit, giving approximately one-half the illumination furnished by the No. 2 unit, has been installed. The practical result is an illumination which is satisfactory in distribution but insufficient in quan-

tity. The present result is sufficiently indicative, however, that the illumination furnished by the No. 2 unit upon which the calculations were based would be entirely sufficient. On the wiring plan the capacity of the lighting outlets is denoted in 16-cp. equivalents. The No. 2 Meridian unit was planned for all the principal outlets and the No. 1 unit for outlets in corridors and similar positions. Ceiling clusters of Meridian units are also used in the assembly room. In the drafting and typewriting rooms the illumination is secured by cord drops adjustable for height and fitted with a 10-inch green porcelain cone shade with white glazed interior surface. Both drafting and typewriting require a high intensity of illumination and entire freedom from objectionable shadows, and this result can generally be most economically and satisfactorily secured by local lights rather than by the use of fewer lighting units of high candle-power.

FIG. 8.—CLASS ROOM, Y. M. C. A. BUILDING.

FIG. 9.—NEWSPAPER READING ROOM, CONGRESSIONAL LIBRARY.

An entirely different solution of such a problem is presented in the illumination of the room on the fifth floor of the New York Post-office, occupied by the International Money Order Division. This room is shown in plan, Fig. 10. Fig. 11 is a photograph of the room taken by flashlight showing the large number of clerks engaged in transcribing money order records by typewriter to large folio sheets. A photograph taken at night by the aid of the light from the Cooper Hewitt lamps installed showed a very uniform general distribution. When the illumination of this room was planned, a system of local lighting by incandescent lamps was considered, involving 135 16-cp. lamps on cord drops, and 9 8-light clusters to provide a general illumination, thus aggregating in all 207 16-cp. lamps which, on the basis of 50 watts for each lamp, would require 10.35 kilowatts energy. It was recognized that the system would be awkward to install, inefficient in operation and unsightly in appearance. An alternative method would have been to install a smaller number of lighting units of high candle-power. Such units, if of high intrinsic brilliancy, would have to be placed near the ceiling to avoid

the glare in the field of vision, and should preferably, even in this location, have diffusing globes to reduce the intensity of light entering the eye by direct reflection from the white paper in front of each clerk. The clerical work performed in the room apparently requires a high intensity of illumination, probably not far from 3 to 5 foot-candles of illumination normal to the desk plane. The Cooper Hewitt lamp was installed experimentally, as the color value does not affect the usefulness of the lamp for this work. The installation has been in service about ten months and has given entire satisfaction to the employees who use it. It has the advantage of an efficiency of .60 to .75 watts per candle when installed without the reflector, combined with a low intrinsic brilliancy.[8]

In order to present in this paper reliable figures of the horizontal illumination, the services of the Electrical Testing Laboratories were secured to make an illuminometer test in the presence of the writer. The full report follows:

8. The Cooper Hewitt System of Mercury Vapor Lighting. C. H. Vom Baur. THE ILLUMINATING ENGINEER, August, 1906.

REPORT ON MEASUREMENT OF HORIZONTAL ILLUMINATION IN THE INTERNATIONAL MONEY ORDER DIVISION ROOM ON THE FIFTH FLOOR OF THE NEW YORK POST OFFICE BUILDING.

GENERAL CONDITIONS.

Light Sources.—Eighteen 21-inch type H mercury vapor tubes, operating on a 115-volt system, two in series, consuming 3½ amperes, placed 12 feet 8 inches above the floor. Tubes had been burned 1,000 hours more or less.

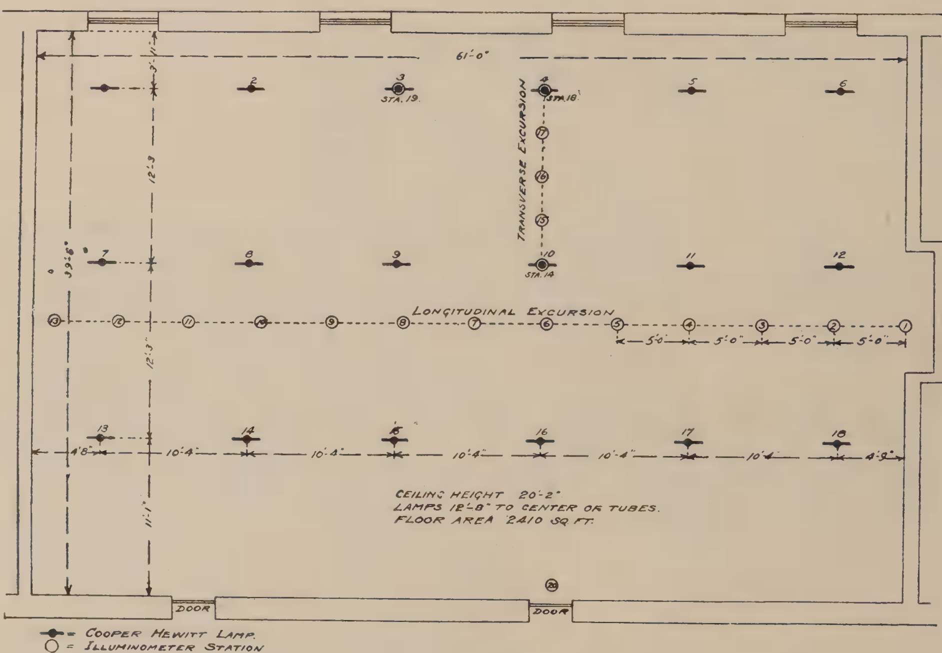


FIG. 10.—INTERNATIONAL MONEY ORDER ROOM, NEW YORK POST-OFFICE.

The Room Illuminated.—Approximately 61 feet long, 39 feet 6 inches wide and 20 feet 2 inches high. Room finished in cream color with dark woodwork trimmings; furnished with flat-top desks, whose illumination is the chief object of the lighting installation.

The location of the mercury vapor tubes and the points at which the illumination was measured are indicated in the attached blue print (Fig. 10). These test stations were selected without reference to the location of the tubes. Stations Nos. 1 to 13 inclusive were laid out at equal intervals, and the numerical average of the values there determined should afford a fair ex-

pression of the average intensity of illumination throughout the area which the test stations represent. The remaining test stations were chosen in order to show particular features of the illumination, such as uniformity and general diffusion.

The horizontal illumination at each point was measured at a distance of 30¼ inches above the floor.

Method of Test.

The intensity of illumination was determined by means of a Weber photometer, especially arranged for work of this character. This instrument, as well as the electrical instruments used, and the observer, were so disposed as to obviate any error arising from objective interference. The lux is used as the unit of illumination in this report. It is equivalent to the illumination produced on a plane surface by a cource of 1 cp. at a distance of 1 meter, the rays of light falling upon the surface perpendicularly. One lux is equal to 0.093-foot candle.

Results of Tests.

Average voltage of system during test 115

Total energy consumed....... 3.15 K.W.

Test Station No.	Horizontal Illumination.
1	35 luces
2	66 "
3	61 "
4	62 "
5	63 "
6	77 "
7	70 "
8	61 "
9	67 "
10	72 "
11	64 "
12	57 "
13	41 "
14—Directly beneath tube	64 "
15	66 "
16—Midway between two tubes	70 "
17	71 "
18	79 "
19	67 "
20[9]	28 "

9. This point was selected as likely to afford the lowest illumination intensity to be found in the room.

FIG. II.—INTERNATIONAL MONEY ORDER ROOM, NEW YORK POST-OFFICE.

FIG. 12.—MONEY ORDER ROOM, NEW YORK POST-OFFICE.

Average of Stations Nos. 1 to 13, inclusive .... 61 luces
Average of all stations....... 62 "
Average variations from mean intensity 15%
Maximum variations from mean intensity 55% (Station 20)
Average luces per K. W. 20

ELECTRICAL TESTING LABORATORIES,
Approved by Preston S. Millar.
CLAYTON H. SHARP, Test Offices.

The average horizontal illumination is thus shown to be 61 luces, or nearly 6 foot-candles, an amount which is probably in excess of the actual requirements. As a satisfactory distribution could not be sesured from a small number of units, and as the type H unit is the smallest unit manufactured, the horizontal intensity cannot be reduced except by raising the tubes, and this would appear advantageous in order to place the lamps farther from the field of vision. While the intrinsic brilliancy of the unit is low, the combined effect of six or more tubes which come within the field of vision from one end of the room is uncomfortable. Probably one reason why no complaint has arisen thus far from this cause, is the fact that during by far the larger number of hours of lighting service the artificial lighting is combined with daylight of greater or less intensity.

In the Bureau of Engraving and Printing, Washington, D. C., 8 type H Cooper Hewitt units are installed in a press room 78 feet long, 44 feet wide and 11 feet 11 inches high, having 22 presses operated by 66 employees. In the New York installation 1 type H unit serves 134 square feet of floor area; in the Bureau of Engraving and Printing it serves 429 square feet. A part of this difference is accounted for by the difference in ceiling height and also by the omission of reflectors over the lamps in of the Cooper Hewitt installation in the the New York installation. In this connection it is interesting to compare the data New York Post-office with that of an incandescent lamp installation in a room in the same building of approximately the same floor area, where work of practically the same character is performed by the Money Order Division. A photograph of the room

referred to is shown in Fig. 12, and its floor area is 2,295 square feet and ceiling height 22 feet. It has a lighting equipment as follows—aggregating 173 16-cp. oval anchored filament incandescent lamps: 30 cord pendants with 10-inch porcelain green cone reflectors, 3 wall brackets, 5 8-light clusters with flat porcelain shades.

The lamps have an efficiency of 3.1 watts per mean horizontal candle, so that the total input with all lamps in service is 8.58 kilowatts. This installation, which is typical of a great many offices and working rooms throughout the country, was made before the advent of high efficiency incandescent lamp units, prismatic and other efficient reflectors and accessories, which would render a modern lighting system of the same type more effective and economical. Fig. 13, for example, is a photograph showing the local lighting system applied to the same work in the Money Order Division in the Post-office, Chicago, Ill. Here the distribution is effected by parabolic metal reflector shades with satin aluminum finish, and 8-cp. oval anchored filament incandescent lamps of 3.1 watt efficiency, horizontal rating. A small amount of general illumination is secured from 5-light wall brackets 20 feet above the floor and equipped with prismatic shades. The space shown being under a large skylight, bracket locations were necessarily depended upon for this purpose.

FIG. 14.—POSTAL SUBSTATION, NEW YORK CITY.

FIG. 13.—MONEY ORDER ROOM, CHICAGO POST-OFFICE.

The desk fixture shown is adjustable in all directions, so that the lamp can be shaded from the eye and the light directed upon the work at such an angle as to prevent its direct reflection from the writing paper to the eye. The distribution curve of a parabolic shade of the type used as determined by the Electrical Testing Laboratories for the D'Olier, Jr., Company, is shown in Fig. 16. The advantages of the

system, as shown in Fig. 13, as compared with that depicted in Fig. 12, lie principally in reducing the candle-power of the local lighting one-half, and in rendering the installation more flexible and sightly. The results in the Chicago office are in general satisfactory, the principal criticism being that the general lighting is not sufficient to prevent a sharper contrast than is desirable between the illuminated field under the reflector and the portion of the desk

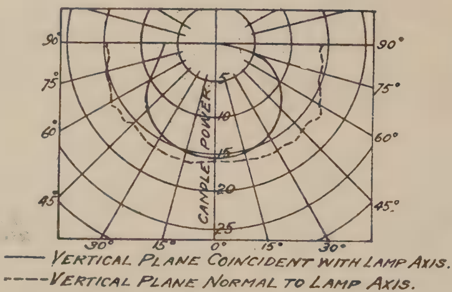


FIG. 15.—DISTRIBUTION OF LIGHT IN TWO VERTICAL PLANES OF 16 CP. LAMP.

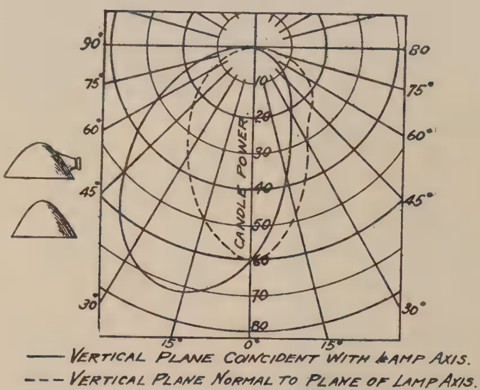


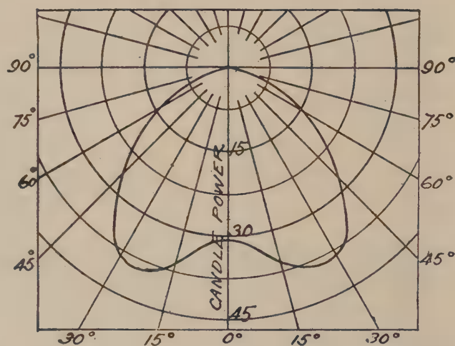
FIG. 16.—DISTRIBUTION OF LIGHT IN VERTICAL PLANE OF 16 CP. LAMP IN D'OLIER REFLECTOR.

outside of its range. The physiological effects of such contrasts have been pointed out by Dr. Louis Bell and others.[10]

An adjustable fixture of the same type, equipped with a parabolic reflector and 8-cp. lamp is also used, mounted on the top of routeing and mail sorting cases in the Chicago Post-office. A view of one side between two rows of routeing cases is shown in Fig. 17.

In Station P in the new Custom House, New York City, cases and furniture of the same character will be fitted with a rigid fixture fitted with a prismatic reflector having a green celluloid cover, in the effort to exclude side reflection and to shade the eye from the glare of adjacent lamps even more than is accomplished by the use of the parabolic reflector. The proposed arrangement is shown in Fig. 16A, which also shows the distribution curve of the reflector selected.

In certain instances it is practicable to provide a general illumination for post-office



DISTRIBUTION CURVE OF LAMP AND REFLECTOR.

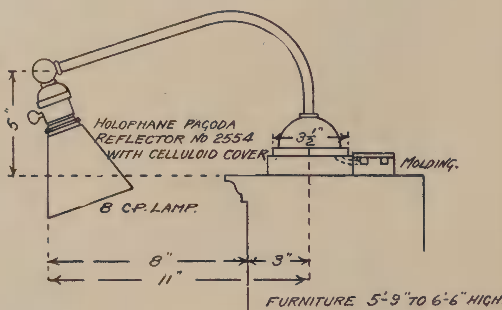


FIG. 16 A.—FIXTURE FOR LIGHTING FILING CASES.

work of the character shown, the 4-light gas arc lamp light being particularly successful when so applied by reason of its low intrinsic brilliancy. The diffusion is also quite satisfactory when used with alabaster or opal globes. The efficiency of a 4-light gas arc lamp with respect to its total flux of light, has been shown by test to be less than that of four individual mantle burners,[11] due to interference of light from the

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10. *Transactions* of the Illuminating Engineering Society, June, 1906.

11. Principles of Illumination from the Standpoint of the Gas Engineer. V. R. Lansingh. Proc. Western Gas Association, May 16, 1906.

group of four burners in the arc. As the result of extended practical experience in the use of both four-arm pendants with individual Welsbach mantle burners and gas arc lamps, the practical advantages of a concentrated light source of low intrinsic brilliancy appear to outweigh the difference in efficiency shown by a laboratory test.

One reason for this apparent discrepancy between theory and practice may be accounted for by the fact that the gas arc lamp is simpler to adjust and maintain, and in general is less liable to derangement and deterioration than four individual burners, each with its separate equipment of shades and accessories. A typical installation of gas arc lamps is shown in the photograph, Fig. 18, of a postal sub-station in New York City.

The inverted mantle gas burner is apparently particularly efficient and satisfactory as applied in postal work-room illumination by reason of the large percentage of light below the horizontal—67 and compared with 45% for the upright mantle burner. Fig. 19 gives a view of a postal sub-station in Philadelphia, Pa., which is equipped with mantle burners of the inverted type.

The examples of interior illumination thus far presented have related to large working offices where efficiency and effectiveness of the system is of prime consideration, and the problem can be approached in a scientific way. In the class of large interior rooms of architectural importance occupied by the public, such as court rooms, assembly and library reading rooms in large public buildings, the architectural and esthetic conditions imposed outweigh the bare engineering considerations. This does not mean that such problems can be approached without reference to the principles of illumination, as is evidenced by many unsuccessful examples, but that accepting the natural conditions imposed in a given case, the final result should be secured by the adroit use of available methods applied scientifically.

FIG. 17.—MAIL SORTING CASES, CHICAGO POST-OFFICE.

Four typical examples of the lighting of

FIG. 18.—SUB-STATION, NEW YORK POST-OFFICE.

FIG. 19.—WEST SIDE WORK ROOM, SUB-POST-OFFICE, WEST PHILADELPHIA.

FIG. 20.—EAST SIDE WORK ROOM, WEST PHILADELPHIA SUB-POST-OFFICE.

FIG. 21.—OFFICE ROOM, WEST PHILADELPHIA SUB-POST-OFFICE.

public rooms, presenting as many radically different solutions of the problem of illumination are exhibited by the following cases:

I. Court room, United States Court House and Post-office, Chicago, Ill.—Photograph, Fig. 23; plan and elevation, Fig. 22.

II. Court room, United States Court House and Post-office, Indianapolis, Ind.—Photograph, Fig. 25; plan, Fig. 26.

III. Court room, Onondaga County Court House, Syracuse, N. Y.—Photograph, Fig. 24; fixtures, Figs. 28, 29.

IV. Newspaper reading room, Library of Congress, Washington, D. C.—Photograph, Fig. 29.

In order to briefly present the important characteristics of the lighting installation in a comparative way, the following table has been prepared showing such data as may prove of interest:

Case I is a room equipped with 12 4-light and 4 3-light fixtures over the skylight with pagoda reflectors No. 2673 and 16-cp. lamps, giving a well-diffused downward light through the ground-glass skylight; 22 16-cp. frosted lamps are located on two main transverse ceiling beams and fitted with pagoda reflector shades No. 2631; 36 8-cu. frosted lamps are located on ceiling beams under skylight, with reflectors; 71 8-cp. bare lamps are installed in the cove about midway between the floor and the ceiling. These lamps are used without reflectors and produce illumination of the wall space above far from uniform. The exposed lights below the skylight beams and the covelights are not necessary in the illumination of the room and are rarely

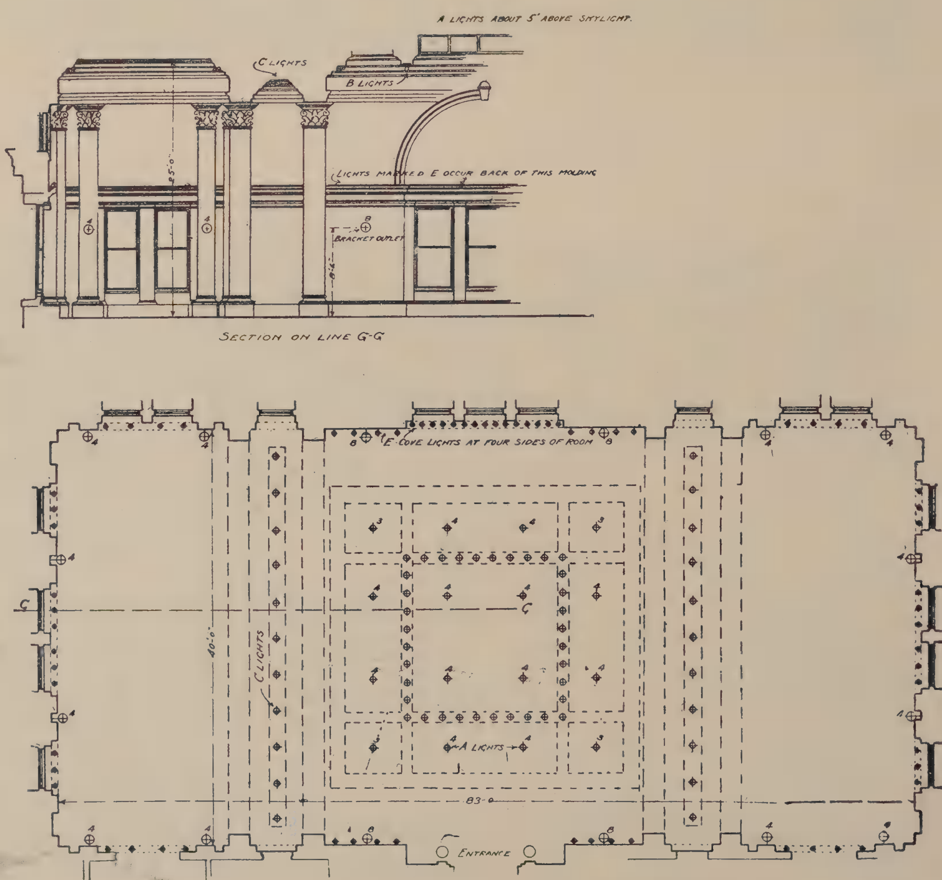


FIG. 22.—LIGHTING PLAN, NORTH AND SOUTH COURT ROOMS, FEDERAL BUILDING, CHICAGO.

FIG. 23.—COURT ROOM, FEDERAL BUILDING, CHICAGO.

FIG. 24.—COURT ROOM, ONONDAGA COUNTY COURTHOUSE.

FIG. 25.—COURT ROOM, FEDERAL BUILDING, INDIANAPOLIS.

used. The remaining illumination is secured by 8 brackets, each with 4 8-cp. frosted lamps and 1 32-cp. lamp in opalescent flame-tip shade, and 4 double brackets with twice the lamp equipment mentioned. The resultant illumination from the lamps above the skylight, studded lamps on ceiling beams and from the brackets is apparently both adequate and satisfactory. The reflection value is high, the finish being in white marble and plaster. The

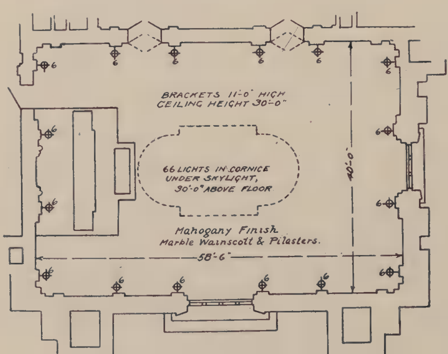


FIG. 26.—PLAN, EAST COURT ROOM, FEDERAL BUILDING, INDIANAPOLIS.

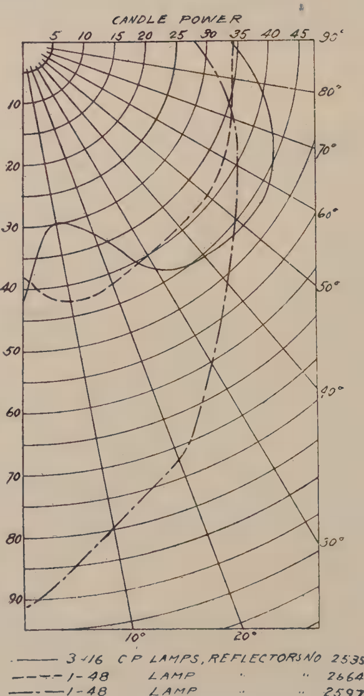


FIG. 27.

lighting equipment is typical of that in four similar court rooms on the same floor.[13]

Case II presents a much simpler treatment. The principal illumination is here secured from 16 brackets of special design,[14] supporting 4 6-inch and 1 10-inch ground-glass ball globes, the former with 16 and the latter with 32-cp. lamps. The brackets are 11 feet above the floor, but on account of the size of the room are within the line of vision. For this reason it was necessary to use diffusing globes by means of which the intrinsic brilliancy is reduced to about one-seventh of 1 candle-power per square inch. The 66 frosted lamps of 16-cp. located under the skylight are used for decorative effect, and aid materially in bringing out the details of the mural decoration.

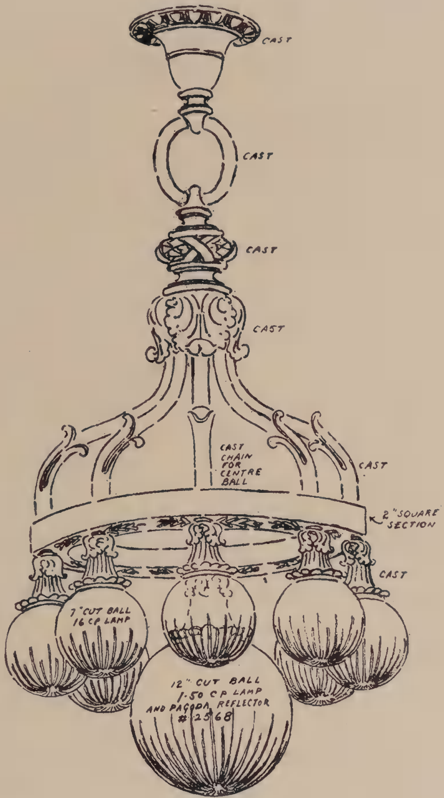


FIG. 28.

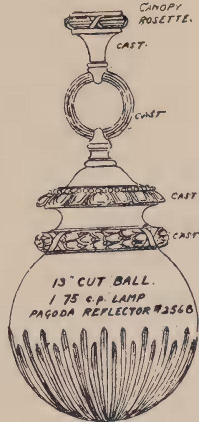


FIG. 30.

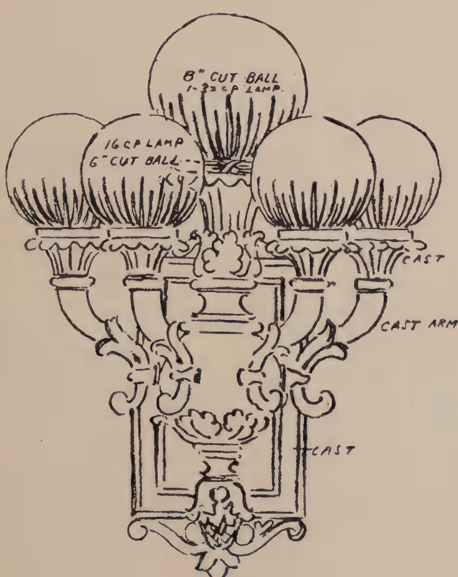


FIG. 29.

The resultant effect is believed to be satisfactory and agreeable to the eye.

Case III. This court room is illuminated by pendant fixtures of the design shown in Fig. 28, and brackets of the type shown in Fig. 29, all equipped with ground-glass ball globes cut as indicated for decorative effect. Pagoda reflectors will be used in the 12-inch ball globes to secure an efficient downward distribution of the light. The lowest point of the pendant is about 12 feet above the floor, but the intrinsic brilliancy of all light is here reduced to about one-ninth of

13. The Illumination of the Federal Building, Chicago, Ill. J. E. Woodwell. THE ILLUMINATING ENGINEER, July and August, 1906.

14. The Illumination of the Federal Building, Indianapolis, Ind. J. E. Woodwell. THE ILLUMINATING ENGINEER, May, 1906.

1 candle-power per square inch. The fixtures have not been placed in service yet, so that no statement of results can be made at this time.

Case IV. This room presents a somewhat different problem from that of the illumination of the court rooms, and one much more difficult. To read newspaper print at an angle of a newspaper rack requires an illumination normal to the paper of about 2 foot-candles, considerably more than is secured by the present equipment according to a rough calculation, ignoring the effect of distant light. The room is 215 feet long by 35 feet wide, and has a lighting equipment of 238 16-cp. oval filament lamps dis-

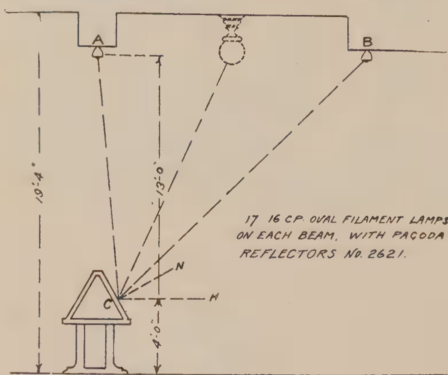


FIG. 31.

tributed about 2 feet apart on the ceiling beams, as shown in the photograph. The height of the lamps from the floor is 17 feet. Each lamp is equipped with a pagoda reflector shade No. 2621.

Independent of the apparent deficiency in candle-power for the requirements of the room as borne out by experience and checked by calculation, this method of illumination appears to have much to commend it. In practice, however, it is open to several objections. The length of the room is such that a very large number of lamps is brought within the field of vision at one time, as shown in the photograph, and though the brilliancy of each unit is small, the effect in the aggregate is to reduce the sensibility of the eye. This effect would apparently be entirely eliminated by the use of a prismatic reflector of conical form with an opaque cardboard cover to cut off the side light. The position of the lamps, however, is not favorable with reference to the natural location of the newspaper racks opposite piers, as shown in Fig. 30. The light rays from lamps on beam *A* strike the paper at a very oblique angle, while the reader cast an objectionable shadow produced by the lamps at *B*. One solution of such a problem would be to provide 4 fixtures in each of the 15 veiling panels, consisting of a 13 or 14 inch ground-glass ball globe with single lamp of 75 or 100 cp. mounted in a suitable holder close to the ceiling. By placing a prismatic reflector above the lamp inside the ball globe the required distribution of illumination is secured with good diffusion and low intrinsic brilliancy. The intensity of the light regularly reflected is also advantageously reduced. A fixture of this type used for corridor illumination in the Onondaga County Court House is shown in Fig. 30. A liberal provision for ventilation of a fixture of this type is made to prevent the undue shortening of the life of the lamp by overheating. The character of distribution sesured by such a fixture with several combination lamps and reflectors is represented by the curves in Fig. 31.

Too much emphasis cannot be placed upon the necessity of reducing the intrinsic brilliancy of an incandescent electric lamp, and the advantages of using diffusing globes of the type described is usually more than sufficient to offset the losses due to absorption.

Moreover, the use of a large, well-ventilated outer globe of ground glass presenting ample radiating surface does not seriously reduce the life of the lamp, as has been shown to result from frosting the lamp globe itself.

DISCUSSION OF THE PAPERS

Mr. E. L. Elliott: Mr. Chairman, it seems to me that both the papers that have been presented this evening form a valuable and permanent contribution to the literature of illuminating engineering. Mr. White's paper, although strictly mathematical and technical, seems to me to be of value comparable to the graphic method that is generally used for determining mean spherical or hemispherical candle power—that is, the Rousseau diagram. So far as I am aware, Mr. White's method is entirely original, and offers, as he states here, a very ready means of determining the data which the illuminating engineer most frequently wants, i. e., the illumination in foot-candles at a certain distance from a certain light-source or light-unit.

It occurred to me while the paper was being read that possibly the use of a separate scale in place of the one permanently printed at the side of the diagram might be somewhat more convenient for regular use; and the diagrams are slightly confusing at first sight on account of the numerous lines on them. Many of these, especially the concentric circles, can be omitted without interfering with the general purpose. I presume that those were drawn on ready prepared paper.

This form of curve is certainly very easy to begin with, requiring only the computing of the square roots of the intensities at various angles; and the reading and interpretation of it is almost equally simple, as he points out.

In the paper by Mr. Woodwell a great deal of valuable information is given—valuable because it represents the results of actual work.

Referring to one of the last examples which he gives, on page 36, of the illumination of the newspaper reading room in the .Congressional library, I think Mr Woodwell treated this, in his discussion, somewhat less vigorously than the case demands. I have been in the reading room and it impressed me at the time as being positively the worst example of lighting for the purpose that I had ever beheld. I think that anyone whose eyes could stand an hour's reading in that room every night ought to congratulate himself. It is impossible to get in any position in the room in which you do not have a line of light staring you straight in the eye. Imagine yourself, for instance, in the front looking down the room, as in the picture. You are standing also probably in your own shadow.

It occurred to me while he was explaining, to suggest as a possible remedy the placing of lights over the reading desks, very much in the manner they are placed over sorting desks in handling mail, which might be an available method if there were no difficulties in the wiring.

I think the Society is to be congratulated on these two papers.

Mr. A. H. Elliott: In looking over these papers, which only came into my hands this afternoon, I am struck very forcibly with one thing that has been developed by a number of men working principally with the electric light, and that is the study that has been given to illumination, as compared with photometric power. As you know, I have been for many years connected with gas, and we have been trying our level best to get out of the cubic foot of gas the greatest amount of light. Well, that may be a useful thing to do, but we are confronted with a problem now that is an altogether new one: the light that we need, we need for the proper use of the eye. That is to say, we need it in conjunction with the eye; and this factor is now for the first time brought out, to my mind, most strongly by these papers, viz.: the importance of distribution of light as contrasted with its intensity.

I also would like to call attention to something that I learned when I was more interested in photography than I was in gas. Some years ago I had a good deal of work to do in conjunction with photographic work and colors, and I was very much struck by the researches of some of the German workers who determined the amount of light reflected from certain sources. The thing that struck me most forcibly was the fact that pure plaster of Paris, clean, would reflect 80% of the light thrown on its surface. Now, if it is true, that seems to me a means of distributing light uniformly without losing very much of it. In other words, it would be better to let the light strike a white plaster surface and then distribute it, rather than have an intense, pointed light that we take a great deal of trouble to tone down by glass globes, which absorb anywhere from 15 to 20 per cent. of the light produced.

Personally, I have to thank Mr. Woodwell for the amount of time and the interest he has taken to present the subject in such a form.

Mr. Lytle: I have been sitting here taking it all in, and have learned a great deal. I think from the practical standpoint Mr. Woodwell's paper is very comprehensive, and we can see from the paper that he has had a very great deal of practical experience. I mean not only in designing lighting systems, but in closely observing the systems that are in practical use, and particularly in post-office work. I think the facts that he mentions of the varied requirements, and the fact that they require more light in that kind of work on account of the distributors of mail being obliged to read writing on different-colored paper and surfaces, are most important considerations. I think that a great many of the

lighting companies, as well as a great many companies that sell lamps, and a great many contractors who install them, absolutely forget to consider these points. Mr. Woodwell makes mention of lighting one of the West Philadelphia sub-post-offices with the Reflex lights, and you have, of course, seen a reproduction of the photograph in his paper. I was interested in that installation and found that the practical results were that the men working there seemed to be very well pleased with the effect, and after all that carries a good deal of weight. The individual using the light is the one very often not considered in laying out a system of this kind, or of any other kind; but, after all, the public will settle the whole question. I don't mean that you have to leave the distribution, the laying out, to the public; but I mean that they will decide which they like the best, and if you try to induce a man to take a low candle-power unit in his house, and it does not suit him, he will take a high-candle power unit, and vice versa; and Mr. Woodwell evidently takes these facts into consideration.

I had occasion in Cleveland a few years ago to study the lighting of the post-office there, and I found the men there were very strong in their opinion as to the kind of lighting system they preferred. If a man thinks he needs a certain kind of light in his work, he will have it, because the men in the office soon discover which kind of light they receive the best results from.

Mr. Gardner: I have been very much interested in listening to these really scientific papers on illumination. The remarks, especially as to the varied amounts of candle-feet and the differing conditions, recalled to my mind a certain problem in the gas and electric light business.

Particularly in the gas business, we are all accustomed to hear that gas is worse than it was a few years ago. "Nowadays when I go home I have to light two or three burners to light my table, where formerly I lit only one," says a customer. Now, after ten years' experience in the gas business, I have heard that remark so often that I have given considerable thought as to why this is, and why people honestly believe that the gas to-day is worse than it was before, and that they really are lighting two and three burners where formerly they lit one.

The explanation I evolved—I don't know whether it is right or not, and I shall be very glad to receive a criticism of it right here in this meeting—was this: that years ago, say twenty years ago, ten years ago, fifteen years ago, the general public was accustomed to a very low degree of artificial illumination. Gas then was a matter of 16 candle-power; to-day it averages very much higher than that—it averages above twenty. Now, these gentlemen twenty years ago who were accustomed to this low degree of artificial illumination, if they wanted to read a book, sat directly under the droplight. Nobody thought of reading except right by the light. To-day we are all accustomed to going into any public place and sitting down and reading anything anywhere, in any part of the room. Therefore, when we go back to our private homes, which are still equipped with the low fixtures or the old number of fixtures, we find perhaps the old conditions; we are very much dissatisfied, and we think, and we say that the gas is poorer than it ever was before.

Now, I would like very much to hear opinions from gentlemen here as to the validity of the explanation which I have evolved for a statement with which certainly all gentlemen in the gas business are acquainted.

I would also like to ask if it is possible to work out and study the conditions as to the candle-feet of illumination that obtained under former conditions in private houses, libraries, public reading-rooms, etc., and compare these with modern public conditions. What are the conditions that obtain, generally speaking, to-day, and what fifteen years ago, in private illumination? What is the standard by which the public has been educated, so that they now say that the illumination is poorer.

Mr. Searle: Going back 22 years ago, when I first went into the lighting business, I can remember when nearly every house I visited as a boy had a fixture suspended from the ceiling, hung up with a hook. The fixture was lowered down to within a foot of the table for reading purposes. Nowadays the light remains high overhead, whether for reading or otherwise. That accounts very largely for the difference, and for the complaint from the older consumers. You will find it is generally the *old* consumer who complains.

Dr. Seabrook: Mr. Chairman, I have no intention of taking much time; I am simply here to try to learn something about illumination. But the problem of the last three speakers, speaking about the present system of illumination, and why it is that people cannot see as well with presumably the same illumination as they did years ago, I think is answered on a somewhat different basis.

Mr. Woodwell. in speaking of this question, remarked that high intensity of illumination did not necessarily produce a better efficiency. That is the first time I think I have heard that point advanced since I read it in the textbooks of my youth, and in Helmholz, whose writings go back fifty years. Helmholz states that the best vision is obtained with an illumination equivalent to that produced by daylight (not direct sunlight) about two feet from a closed window on a clear day. That, taken as a standard, is the amount of illu-

mination with which one can easily detect differences in volume of light, shadows, etc.

Over thirty years ago there was a very wide discussion, and prizes were offered by eminent men for essays upon the question of illumination. One essay summed up the subject in these words: that visual increase only takes place within the limits of medium illumination, and then as the intensity is increased, visual perception increases about as the logarithm of the intensity. The reason, as it seems to me, why the eyes give out with the same illumination that they had formerly, is not a question wholly of position, but is rather due to this fact. All civil service examinations give practically no attention to the near vision; it is only the far vision that is considered.

As time goes on, and more work is done at night, and the eyes become fatigued, the tendency is to increase the intensity of illumination without regard to its quality; and, as Dr. Bell stated in his paper last spring, when the intensity of the illumination is increased the pupil contracts, mostly through the actinic rays, I believe; and with that contraction the eye becomes more fatigued. In proof of this I would mention that I have known many people, surgeons and the like, to resume the old kerosene burner of sufficient intensity. It is practically impossible to increase kerosene light beyond the proper intensity. The proportion of actinic rays in kerosene to electric light of equal intensity is about 1 to 10. With an equal candle power there would be 1-10th the chemical rays in the kerosene as compared with the electric light; and I have known many a man to resume the old kerosene burner and find the illumination sufficient.

Dr. Sharp: Mr. President, Mr. Woodwell suggested a point in his paper which I think is likely to be overlooked sometimes in planning systems of illumination and which is of a good deal of importance. This suggestion is in connection with the diagram which he gives of the angles at which the light falls on those newspaper desks in the Congressional library. I don't suppose that there is any question but that there is a sufficient amount of light in that room. The illumination on the newspapers is not a good one, not because there is not light enough, not entirely because there is the glare of light in the eyes of the reader, but because the light does not fall on the newspaper at the right angle. If we are going to illuminate surfaces we must consider the direction from which light comes, in regard to the proper illumination. If we have a sitting-room or a library in our home it is not sufficient to try to illuminate that room with, we will say, one good-sized light up near the ceiling, not because it will not produce enough illumination, but because, in order to utilize that amount of illumination we have to hold any book or paper that we are reading in more or less of a horizontal position. Holding the paper up requires that the light should come, not from the ceiling, which brings the light down to the proper point. Then the rays which we wish to use will have the proper intensity. In other words, the horizontal rays illuminating a vertical plane are more useful in those circumstances than the vertical rays which illuminate a horzintal plane. Consequently it is in all cases by no means sufficient to consider the illumination on a horizontal plane in a room; we must take account, and very marked account, of the illumination on a vertical plane in the room, and also the normal illumination in many cases.

Referring to Mr. Woodwell's paper, on page 15, he has given in the diagram the illumination of the Y. M. C. A. classroom very nicely, it seems to me. He has shown what the value of the illumination in that room is in a line across it, but we must remember that that room has a blackboard at one end or at one side, and I think it is at the side that the horizontal illumination, as shown by this diagram, is the weakest. Now, that may not mean that the vertical illumination is the weakest, but certainly from this data you can form no idea as to the efficiency of the illumination of that blackboard. It would be necessary to supplement this diagram by a diagram showing the vertical illumination along the wall in order to tell the whole story. It is another case in which the direction in which the light comes is a matter of very considerable importance in the consideration of the question of illumination.

The point which has been brought up as to the difference of our standards, or the difference of eyes, or the difference of something, in judging of illuminations, is very interesting. I think there is no difficulty in going back to the records to show that the standard of illumination has steadily increased; that if you go back to the days in which illumination was done practically entirely by candles, and compare that with the illumination which was produced by open gas, you will find that the illumination in the latter circumstances was much higher. The introduction of electric light, which lends itself to very many differing forms of treatment which the gas flame is incapable of submitting to, has also produced a tremendous increase in the standards of illumination. Now, while the physiological effect to which the last speaker referred undoubtedly has its influence, yet I am inclined to think that the reason why the gas of to-day is not as good as the gas of twenty years ago, is that we have simply become accustomed to a higher degree of illumination, and find that the illumination to which we were formerly accustomed is an insufficient one. If you will go along the business street of to-day, particularly in a country village, you will

somewhere come across a store that is lighted with kerosene lamps. That is the store of a very unprogressive merchant. Twenty years ago that store was well lighted, it compared well with its neighbors, but at the present time it looks like a spot of dismal darkness on the street. Why is it? It is simply because his neighbors have installed other means of illumination which produces a better effect, and by comparison the store of the other merchant seems not so well illuminated, though it is not differently illuminated from twenty years ago, when that method of illumination was considered entirely sufficient.

The question has been raised by the gas-lighting people upon the introduction of the mantle burners. This question is the same as the question which, to a certain extent, confronts the electric lighting people of the present day when electric lamps of a higher illuminating capacity are produced. It is this: what is going to be the effect of these higher illuminants upon our revenue? The fact has been with the gas people that the effect of an illuminant like this has been that they have sold more gas. Their revenue has increased; that is to say, the public has taken the value of its bills, not in increased bills, but in increased light; and the result has been largely increased illumination. And that is likely to be the effect also of the introduction of higher efficiency in electric lamps, and is only another indication of this constant toning up of the average scale of illumination.

Mr. Thompson: I think that every illuminating engineer ought to study to be an oculist as well as to be an egineer. The eye is one of the most complex instruments, and seems to be endless in its intricacies and its behavior. It is like a child or like an animal; you think it obeys you, but it does not. It has ways of its own. In dark spots and very light spots the eye is uncontrollable. It is hurt in a room where there are dark shadows and bright spots.

I learned from experiment that for proper diffusion, intensity, etc., we need a large *quantity* of light, and in consequence of that experiment I have always used in the evening a 32 candle-power light with one of these green outside shades. At the same time we must have other lamps in the room so as to get the general effect. You must not have the rest of the room dark.

Mr. Gardner: Mr. Chairman, I want to say a word in confirmation of some of the last remarks. I have been actively connected with the commercial and practical side of electric lighting. At the last convention of the National Electric Light Association we had a very interesting paper on the introduction of the tantalum lamp. The opinion was expressed that the use of higher efficiency lamps would cut down the revenue from current. I then stated that that had not been the experience of gas companies in the introduction of the Welsbach lamp. I want to agree with Dr. Sharp. I think that is a very sound policy, a sound policy to give the public the best service you can for the money; they will take more of it every time.

The Chairman: I would suggest that somebody obtain data on an actual intrinsic brilliancy of daylight illumination through a ground-glass window. I think it is very much less than any data given in the paper. The lowest figure which Mr. Woodwell gives in the latter part of the paper is one-ninth of a candle-power to a square inch. I think it will be found that in a well-illuminated room in the daytime, with ground-glass windows, we will have as low as 1-50th or 1-100th of candle-power, and that is what we want to get to. Our sources of illumination are entirely too bright.

I may say that I have made quite a number of such measurements myself, but I am not prepared to give them now as accurate, but I presume that they are as nearly accurate as those given in the paper. Is it Mr. Woodwell's desire to close the discussion?

Mr. Woodwell: In view of the lateness of the hour I have nothing further to say. I want to thank you for your very kind interest in the somewhat tedious presentation of the subjects in the paper.

The Chairman: I wish to add that I am sure I voice the sentiments of the members in thanking Mr. Woodwell very kindly for his treatment of the subject.

Mr. Gardner: Mr. Chairman, I want to call the attention of the members to a very able editorial in the last issue of the "Electrical World" entitled "The 16-candle-power Standard."

The Chairman: I have read the article in question, and I wish to place myself as emphatically opposed to the ideas presented in the article. (Laughter.)

Mr. Williams: In line with your remarks, Mr. President, about the intrinsic value of illumination, I have had an experience in my home that convinced me that we did have too much illumination. In the dining-room we have one of the large fixtures, domeshaped, with two 16-candle-power lamps. I changed them to 8-candle-power, and found that one of them burned out. Now I find that one of them gives sufficient light for all practical purposes.

In the reading-room or library we have a regular drop chandelier, with three 16-candle-power lights, and a light in the hall which shines into the reading-room. We find in reading that we get better results by having the hall light turned out than we do by having it on.

Papers Read Before Technical Societies

VARIOUS TYPES OF LAMPS AND PRACTICAL HINTS ON ILLUMINATION

BY S. B. BURROWS.

Read before the Association of Edison Illuminating Companies.

The value of illuminating engineering is being more thoroughly understood with the development of this recently recognized science, for companies are realizing as they have not done before that the satisfaction and good will of the customer, which is a most important asset of any company, can best be secured by giving all the illumination possible from every kilowatt-hour of current used.

The illuminating engineer's duty does not cease when an installation has been planned and installed, but he must seek to educate the consumer to the proper use of his light units so that he will get the greatest efficiency out of his lighting service.

The available data bearing on this subject is meager, and it has been left to those who are making a specialty of this science to learn by experiment and study the effect of different units upon the optics, and the source best adapted to a given purpose, with accessories, distribution and control.

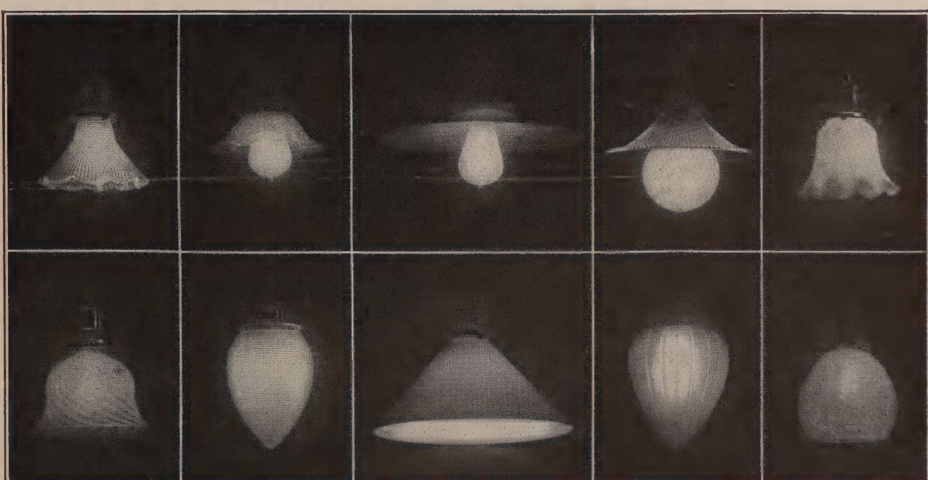
In discussing the subject of "Various Types of Lamps and Practical Hints on Illumination" the writer will aim to present the types of lamps best suited for various purposes of commercial illumination.

Practical illumination must include usefulness, economy in distribution and control, artistic and æsthetic arrangement, and harmony with optical laws.

Reversing the order and referring to the last first, opticians insist that the majority of weak and strained eyes are due to artificial light, such being either too intense or not properly shaded. On this point the following law should be followed in practically every illumination: No light should enter the eye direct from the luminous center.

In treating the several heads, it may be well to generalize, rather than outline minute details of arrangement, because persons' tastes differ, and the illumination must not only comply with general rules, but must also please the taste of the customer; therefore, fixed rules cannot be established, except along general lines.

The most recent development of general illumination has been toward the larger and more intrinsically brilliant units, for, while there has been a markd increase in the efficiency of lamps consuming from 100 to 600 watts each, the smaller units have not made corresponding progress.



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1. HOLOPHANE REFLECTOR. A GOOD TYPE TO USE. 2. FANCY GLASS REFLECTOR. 3. WHITE PORCELAIN SHADE. POOR FOR READING OR WRITING. 4. PROPER MERIDIAN REFLECTOR. 5. WHITE PORCELAIN. 6. OPAL REFLECTOR. 7. HOLOPHANE GLOBE. A GOOD DIFFUSION. 8. READING OR WRITING SHADE. GREEN EXTERIOR, WHITE PORCELAIN INTERIOR. 9. GROUND GLASS INTERIOR. A FAIRLY GOOD DIFFUSION. 10. OPAL GLOBE. POOR DIFFUSING SURFACE.

In the paper, however, presented by Mr. Wilcox at the National E. L. Ass'n. Convention at Atlantic City, data was presented on the new metallic filament lamp in sizes ranging from 30 to 100 watts with an efficiency of 2½ watts per candle and a life of eight hundred hours. This lamp indicates encouraging and immediate prospects in the smaller units, and it is to be hoped that the rumors of greatly increased efficiency in incandescent units will in the near future be fully verified.

Reflectors, globes and shades play a very important part in illumination, both for reflecting and diffusing the light; and very often the effect of well distributed units is spoiled by the unneccessary or improper use of reflectors or globes.

To illustrate the wide differences in this class of ware the accompanying illustrations are presented.

The best uniform illumination is obtained by distributing small units over the space to be lighted; but this is not always practicable, for one must consider the architecture and purpose for which the space is used.

Many features must be considered, and one of the most important is the color scheme.

We know that colors are noticeable on account of the reflection of certain rays of light, others being absorbed; and this will make a wide difference in the illumination of two rooms of opposite colors, with the same source of light.

For instance, white will reflect 85 per cent; yellow, 45 per cent; light pink, 35 per cent; light blue, 25 per cent; brown, 15 per cent; black, 5 per cent; chocolate, 4 per cent. So that the number of candle feet necessary in a room decorated in white would have to be increased for a yellow or other colored room in proportion to the light absorbed.

The question as to which scale is the best to follow in figuring a given illumination is a moot question, but, in the writer's opinion, the best standard is the candle-foot, though he has satisfactorily used the scales of watts per square foot and watts per cubic foot, the former when the object to be lighted was on a plane surface, and the latter in general illumination, such as church lighting.

Of course, as the source of light is raised, the light on an underlying surface will diminish according to the law of inverse square, *i. e.,* that the light from a given source varies inversely as the square of the distance; so that the scale of watts per square foot will vary with the height of the lamps and their efficiency.

The following hints on illumination are offered for the several classes of buildings as indicated:

THEATER LIGHTING.

In every building the illumination and accessories must correspond with the architectural lines and the decorations.

The quality of light in a theater must be soft, well distributed, and shaded from the eye in all instances, for the eyes are tired and distended after having looked upon the brilliant footlights, and the mellow light is needed as a restful contrast. It will be noticed that the decorations are usually in some dark color to correspond with this idea, as also to give the appearance of space.

Every lamp should be concealed from view or equipped with a globe. Frosted lamps will also serve the purpose of diffusion.

Studded lights are the most appropriate in this class of illumination, as they can be made to carry out the line of the buildings and the distribution is of the best.

The incandescent lamp in the 16 or 32 candle-power is the best lamp for this purpose, on account of the quality and quantity of light in each unit.

Electroliers should be tabooed, as they tend to concentrate the light.

Under the balcony the units can be best arranged by concealing them in hemispheres, and on the forward side of the balcony units can be best arranged throwing the light forward, the units being high enough to be out of the range of vision. The same arrangement is good for the extreme rear of the theater, the units being placed at the junction of the ceiling and wall.

Frosted four candle-power lamps placed around the usual arch of the boxes will add materially to the artistic effect.

The lighting of the lobby is a different proposition, as brilliancy is desired. Electroliers can be used to advantage with the side wall brackets, or the brackets placed around the top of the pillars, or the units themselves can be artistically embedded in the decorations.

CHURCHES.

In this class of lighting the engineer encounters a great diversity in architecture, and therefore a great diversity in the styles of illumination exists. For instance, there is the Grecian or Corinthian, where studded lights would be out of place, as, in fact, they would be in most of the ancient types of architecture. But in the Gothic and modern this style of lighting can be used to advantage, as the general lines of the building are plainer than in the Grecian.

The denomination of the church will often make a difference, for you would not plan to illuminate an Episcopal or a Roman Catholic Church with studded lights. These two church bodies are symbolic and present to the worshiper the Almighty in symbols, making the chancel beautiful and æsthetic, and denoting some attributes of the worshiped. So the general illumination must

be along the same lines, with fixtures appropriate to the building, keeping out the more modern styles.

There is the other extreme, as in some of the Protestant churches, where the puritanical ideas of plainness and severity find expression; here the studded lights can be used, arranged in the shape of a cross, a star, a circle, or a Maltese cross, each denoting some religious theme, but in plain lines.

A good style of illumination for the church is cove lights in conjunction with a general illumination, the hidden light to be switched on when the sermon begins and the visible sources to be dimmed, which will shed a soft light over the church, appropriate and not injurious to the eyes.

The control of these lights should be elastic, so that from one-eighth to the whole can be used, as desired.

Incandescent or meridian lights are the best units, but the writer hears of satisfaction with the Nernst.

DANCE HALLS AND THE LIKE.

To take the other extreme in lighting, let us consider the dance halls and ballrooms.

The first requisite is uniform illumination, with no shadows, and this can best be accomplished by studding small units over the ceiling and upper walls, and then, if there are any recesses, lights to be arranged in these in conformity with the other lighting.

The accompanying pictures will illustrate the correct lighting of a ballroom.

Arcs or Nernst are not permissible, for they give an impression of light and shadow rather than of uniform illumination, and their effect upon the face is not so pleasing as the incandescent light.

BANKS AND OFFICE BUILDINGS.

The lobbies of this class are generally of the same style as theater lobbies.

In all cases of bank and office lighting there are two considerations, one of the general illumination, and the other the placed lighting over the desks.

The general illumination in banks should be designed, not only to illuminate the lower region of the public space, but to throw enough light on the ceiling and upper side walls to bring out the decorations and lines of the building.

Studded lights can be used to good effect.

There are three points to be noted in the placed lighting for the use of the clerks. The light sources should be shaded from the eye by a dark-colored shade, preferably green on exterior and white porcelain finish inside. Frosted lamps should be used to prevent striations, and the light source should not be too intense. An illumination of from 2 to 4 candle feet is plenty. In other words, an 8 candle-power lamp eighteen inches to two feet from the surface to be lighted.

This illumination is the correct standard for reading. The light should come from behind the left shoulder. For writing, also from the left, but more out forward, so as to prevent shadow from the pen or hand.

The writer has not seen anything but incandescents used satisfactorily for the illumination of banks.

The arc and similar illuminants would not give satisfaction, on account of the size of the unit and its tendency to cast shadows, certainly not enhancing the appearance of the interior.

The lighting of an office building is practically the same as in a bank.

For the desks, etc., a line could be run around the room at a distance of two feet from the floor, with plug outlets at intervals to accommodate a given number of desks. This would arrange for the placed lighting.

The general illumination should be preferably from above, as side lights would tend to throw shadows when one is writing at the desk, and, while the bank's working force is enclosed behind a partition, the office buildings or rooms are usually open, and the general illumination will effect the light on the desk to some extent.

In our Brooklyn office we use the arc concentric diffuser, with no placed lights, and the illumination for writing or reading is as near perfect as it could be and is free from shadows. This lamp, however, is not attractive in appearance and might not be acceptable in a bank or small office; but for large office rooms the illumination is good.

STORES.

Perhaps the largest part of our light load comes from this class of business, and the writer has specialized somewhat on this field of illumination.

The first point we notice in talking with a storekeeper is that he wants all the light he can get for a given sum of money. It is all right to talk about artistic effects to him, but he is more interested in dollars and cents and economy in lighting. The advantages of an attractive store are recognized, but the storekeeper wants to be sure that he can get them at a reasonable cost.

What general rules can be followed to this end?

First we will consider the several kinds of stores, as to interior lighting.

The writer has found that, in cases where economy is the first consideration, the best result is generally obtained from incandescent units at a height of from eight to ten feet from the floor, and with the arc from twelve to fifteen feet high; the units between these in size range correspondingly.

FURNITURE STORES.

One of the latest propositions dealt with has been a furniture store, and the installation consists of high efficiency units in the several sizes.

Furniture shows up better under a yellow light than under a white light, and when a patron purchases he will in most cases use

the furniture in a home with the first quality of light, and wants to know how it is going to look when there.

Then, again, the high efficiency or other incandescent lamps are easily renewed, while in all cases the lamp shedding white light must be trimmed, making it necessary to move the furniture, with the liability of scratching.

For carpets, also, the yellow light is preferable, and a unit of about 100 candle-power or more, fitted with a reflector to throw the light on the carpet (which is usually hung on a movable form), will prove satisfactory.

The units in this class of business should be of individual control, with the possible exception of the main floor, for many times the salesman will need only one or two lights at a time, and they can be readily used as required without wasting current. A good arrangement is to have a row of pilot lights, controlled by a switch, at the entrance to each floor.

In using the new high efficiency unit it is advisable to hang the units ten to twelve feet from the floor, and have them fitted with the Style C shade, as the light will diffuse of itself below a certain plane and at the same time give greater efficiency with the C reflector than with Style D reflector.

MILLINERY STORES.

The arc or Nernst should be used for this business, as the white lights show the delicate colors to best advantage.

The writer's belief is that the arc is better than the Nernst for this class of illumination. The concentric diffusers are used in Brooklyn millinery stores with satisfaction.

MEN'S FURNISHINGS.

The same principle as to color will apply to clothing stores, though perhaps evening clothes, since they are to be worn under the incandescent light, should be fitted under the incandescent unit.

For a men's furnishing store the cluster, either the arc burst or the pagoda arc, is a good arrangement; and such units are attractive and efficient. In one such store we have recently changed three arc to four Benjamin arc bursts, and with a saving of 400 watts the resultant illumination is a big improvement.

The Nernst lamp or the high efficiency lamp is being used in Brooklyn in this class of stores. The Nernst gives the better color value, and in the two and three glower size the illumination is good.

The arc should not be used in small stores, for two reasons. First, the size of the unit and the usual height of ceilings in small stores will not permit of good diffusion; and, secondly, unless a number are installed, shadows are frequent.

JEWELRY STORES.

There is a diversity of opinion as regards this style of illumination, some engineers claiming the white or bluish light should be used, others that the incandescent is best.

The advantage claimed for the arc lamp is that it accentuates the bluish tinge in diamonds, and that the larger the unit of light the more intrinsic brilliancy the diamond will have.

As to the other classes of jewelry, the incandescent unit is, in the writer's opinion, decidedly the best light.

A good arrangement of units is to have a cluster or 187 to 250 watt high efficiency lamps with D shades in the center of a store, placed high to give the store an appearance of brightness, and have special lighting either on cord pendants over the cases, or reflectors inide the cases, the latter being the better, for the two-fold reason that the observer cannot be between the light source and jewelry and that less light is necessary.

Studded lights make a very pretty store if the decorations will allow same.

Most other stores are in the one class in so far as interior illumination is concerned, and the principles presented will apply to cigar stores, drug stores, butcher stores, grocers, saloons; practically all call for the same illumination, and if there is any difference at all it is in the brilliancy desired. For instance, a drug store, saloon or cigar store may need more light than the butcher or grocer, and the light ranges from 1½ candle-feet to 5 candle-feet, or, if watts per square foot, from 1 to 3 watts per square foot, determined by color of store, height of room and units used. The number of lamps required for a given service equals the above factor multiplied by the area in square feet, divided by the wattage per lamp.

No definite rule can be made as to the watts per square feet or candle-feet needed in an installation, for so many things must be taken into consideration that no definite figures can be given until these factors are known; therefore, no scale is presented in this paper.

DEPARTMENT STORES.

It would seem at first glance that, as the department store is a consolidation of the smaller stores heretofore considered, the illumination for each department would coincide with the corresponding store; but there is a factor which governs this, *i. e.*, uniformity. For large spaces of this kind the arc lamp without doubt is the unit to be used ,as the color values are good and the majority of goods shown are "day goods," though department stores are providing separate rooms for the exhibition of evening goods. Incandescent and arc lamps should not be used in the same space for the same purpose. That is, while arc lamps may be used for the general illumination, in-

candescent units should not be used also for general illumination in that room, but may be used for special purposes, such as lighting show cases; to alternate the general illumination between arcs and incandescent would be very poor arrangement. An opalescent globe should be used with arc lamps, to remove the glare and improve the color values by filtration.

WINDOW LIGHTING.

There are two distinct divisions in window lighting, the concealed and the open, and each serves its purpose. One is to attract attention to the store itself, the other is to show the goods in the window.

It is obvious that the usual border arrangement of the lights would not show goods to the best advantage, first, because most of the light which is on the horizontal is being thrown on the street, and, secondly, the rule which was presented in the first of this paper, that the light should not enter the eye direct from the luminous center, is being violated. When one looks at a window lighted with visible units, the light itself attracts the eye, and the sight is for the moment blurred, so that when we look at the goods they are not distinct; it has been the light units which attracted us, not the goods.

Take the opposite, concealed, reflected light—the window is bright, but the light is centered on the goods, which reflect the light to our eyes, attracting our attention to the display and not the source of light.

When the border lighting is used, a frosted lamp should be utilized to reduce the intrinsic brilliancy, and an 8 candle-power unit is large enough to serve the purpose of attracting attention.

In the concealed style there are two divisions, trough reflectors and cone reflectors, including in the last all cone-shaped reflectors, whether moulded glass or silvered.

The trough reflector should be used where the window display rises from the bottom of the window in the shape of models for dresses, or where the back of the window is used as the distribution of the reflector is toward the rear and downward.

The cone reflector should be used where the base of the window alone is to be used, so as to concentrate all the light upon the goods.

The Nernst or units of the same size are used satisfactorily in Brooklyn with reflectors to throw the light down, the unit being high enough not to interfere with the sight.

The writer has in mind a window where the trough reflector is used in conjunction with an electrolier, but the latter is fitted with holophane globes, which eliminate the intense light factor by diffusing the light. This arrangement is both attractive and efficient.

The tendency of the cone reflector is to produce spots, while with the trough reflector the illumination is uniform and even.

In lighting the window with either the border lights, trough or cone reflectors, the units should be on alternating switches for purposes of economy.

PICTURE GALLERIES.

The best arrangement for this class of lighting is the trough reflector, for the reasons as above given.

A new arrangement, at least to the writer, was suggested by the desire of a customer to light a small gallery economically, both as regards wiring and use. The arrangement installed was a Frink reflector on a pivot, run along the center of the room and placed high. A handle was attached so that the reflector could be turned to either side of the gallery, the result being highly satisfactory.

In the Metropolitan Art Gallery the luminous arc is being installed, and the experts of the gallery are of the opinion that this gives the best light of any artificial source.

RESIDENCE LIGHTING.

The class of residences considered will be those belonging to the "middle class," where economy is necessary; where the person is willing to spend a large amount the engineer can give full play to the artistic, but most of our residence business is with the people who practice economy.

PARLOR.

This room is used for entertaining and receiving callers only, so the illumination should be general. In the average room of twelve by fifteen feet a center electrolier with the units extending about a foot from the ceiling and four or five 8 candle-power lamps will give good light, the units pointing outward at an angle of 45° and equipped with either an etched shade or holophane goods. One or two plug outlets can be utilized for a lamp, fan or other apparatus.

In a room of this shape the center fixtures are sufficient, but when the room is long and narrow side wall brackets can be used to advantage.

One point in this style of illumination is to have the lights pointing downward, for it can be readily seen that otherwise the light would be thrown on the ceiling and wasted to some extent. The side wall brackets can be fitted with holophane reflectors in ground glass shades, and can be either pointing upward or downward. This is a great deal a matter of taste, as both arrangements can be made to conform to the other illumination by the means of proper shades.

For the lamp, which is ornamental rather than useful, a small candle power light can be used, Two 4 candle-power units will be sufficient is most cases, and in any case two 8 candle-power would be enough,

which would be determined by the density of the art glass canopy.

SITTING ROOM.

This room is used for sewing, reading, and is the living room of the house, so that general and some special illumination is needed.

A center fixture with three or four outlets, and an outlet near the desk will prove satisfactory, but each purpose must be considered.

In reading, a light of 2 to 4 candle feet is plenty, and the same on the desk or for sewing; and while, theoretically, a light from above and behind is the best for reading, the writer's own taste is for the old-fashioned reading lamp with a white enameled interior and green exterior—first, because the resultant light is good, and, second, the eyes, on being lifted from the book, do not encounter the same intensity, but are rested by the soft light diffused by the green shade; while with the other style the light is practically the same whether one's eyes are on the book or not —in fact, in all home lighting, if the illumination be uneven, the eye is rested in the change from bright to less bright spots.

For sewing an extension cord can be attached to an outlet and the lamp hung directly over the machine.

DINING-ROOM.

The one point to be illuminated in this room is the table, and this can be done by one unit with a large reflector. The reflector can be covered with some dark material in keeping with the decorations, either crepe paper or some texture, which will serve the purpose of an expensive glass design.

Side wall brackets are not essential, but can be used if at any time a more general illumination is desired, such as when the guests are seated around the sides of the room.

KITCHEN.

The kitchen of to-day is not the large one our ancestors were accustomed to, and in the average home one unit in the kitchen is sufficient.

In the March issue of the *Electrical World* Messrs. Cravath & Lansing present the following points: To have a 4 candle-power unit over the sink, stove and table, with reflectors easily kept clean, on account of the grease, etc., in the kitchen; these units on brackets pointing downward to have light below 45°.

The article admits that with this arrangement, the equivalent of a 16 candle-power unit, the general illumination will not be good. The deduction, therefore, is that a center unit for general illumination would also be necessary, and that the three 4 candle-power units would be used in concentrating the light over the sink, table and stove only. In a small kitchen such units would be unnecessary, as a lamp placed high, with a good reflector, will shed plenty of light for all purposes and at the same time be economical. In a large kitchen the arrangement suggested would be ideal with an 8 candle-power or 16 candle-power unit for general illumination.

HALLS.

In the halls a bright light is not necessary. In the lower hall or entrance an upright fixture from the newel post in a foyer hall gives good illumination, though the overhead light is to be preferred, for the tendency of the unit upon an upright is to throw the light up, whereas it should be thrown down.

A ground glass or opal sphere can be used, and is perhaps more artistic than a common reflector or shade, the lower hall unit to be controlled by a two-way switch.

In the upper halls a light at the head of the stairs on a side wall bracket, to serve both for the stairs and hall, and if the hall is long, another unit at the opposite end, will light the hall well.

BATHROOM.

An 8 candle-power unit on each side of the mirror, either with a shade or frosted lamp, will suffice, controlled by a switch at the entrance.

BEDROOMS.

The most economical arrangement here would be to have a center fixture of two or three lights and use the movable brackets, so that the light can be used at the dresser, or, if a reading light is desired, it can be placed near the bed. In a small or hall bedroom a side wall bracket with an 8 candle-power lamp is enough.

The most convenient arrangement is to have two 8 candle-power units on each side of the dresser, controlled by a switch on the side of the dresser or wall, the center fixture to be controlled by a switch by the door and fitted with proper reflectors.

In all houses fitted with electric light, an extra switch should be provided in the bedroom controlling one light in each room on the first floor and the halls, so as to be able to light these rooms instantly in case of emergency.

The turn-down lamps can be used to splendid advantage in residences. There are many places where a bright light is not required continuously, but where a dim light is of great service. The turn-down lamps fill this need fully and at slight operating cost. Every residence using electric service should have a supply of these lamps.

FACTORIES.

In factory or machine shop lighting the problem is generally the same as in a large office building.

Each operator should have a unit over

his machine, and this will hold true in most all factory lighting and the like. The incandescent lamp should be used for special lighting.

In foundries, etc., where the walls are dark and the light is not so much on a special line a lamp is needed to throw the light down and to be near the color of daylight. The arc does not meet both these requirements, and the lamp which has proved most satisfactory in Brooklyn is the Nernst lamp, as the unit is small and can be distributed, and the efficiency is high.

The light from the arc is absorbed by the side walls, and the Nernst distribution is below 30°.

SIGN LIGHTING.

The tendency of a customer is to put too large a unit in a sign, thinking to make a greater display, whereas, he is more likely spoiling the effect of his sign.

The smaller the candle-power in a lettered sign, the more distinct is the outline of each letter; with a unit too large the sign presents a blur.

A 4 candle-power unit is large enough for any ordinary sign and a 2 candle-power unit has proven satisfactory in outlining letters.

For the panel sign a 4 candle-power lamp is sufficient, authough 8 candle-power will of course give added illumination; if a reflector is placed above the upper lights the sign will prove more readable.

SPECIALTIES.

Several types of lighting uits have recently been pushed commercially for special uses.

Luminous Arc.—The luminous arc is used quite extensively in many cities, notwithstanding the cost of the lamp, and it certainly attracts attention by the brilliancy and color of its light. It probably has a permanent field within a limited scope, but its advertising value will probably suffer as the number of lamps in use increases. For general illumination, independent of advertising uses, this lamp is not at present well adapted.

Cooper-Hewitt Tube.—This type of unit is occupying a field in which it is giving good service. For photographic work it is very successful, and its use in factories and large buildings is becoming more general. The predominant violet rays are objectionable, although not injurious to the eyes.

Moore Tube.—The Moore Tube is now being energetically pushed by the manufacturers, and is giving satisfaction in a number of places. Its color is more pleasing than the Cooper-Hewitt and its efficiency is attractive, though its use is limited at present to large floor spaces. The commercial development of this type of lighting will be watched with interest.

FLUORESCENCE AND PHOSPHORESCENCE

By Edward L. Nichols.

Read before the Franklin Institute, March 29, 1906. Reprinted from the Proceedings.

The weird shining in the dark of certain bodies; the gleam of sea water when disturbed and other allied phenomena must have been known from the earliest times. When phosphorus was discovered, in the 17th century, the property which it possesses of glowing with a greenish light attracted universal wonder, and from that time the name of phosphorescence was given to all cases of the emission of light by bodies at ordinary temperatures.

At first it was imagined that the presence of phosphorus was indicated wherever phosphorescence occurred or perhaps that there was a group of allied bodies to which the phenomenon was ascribed. When, for example, in 1676, Picard noticed that upon shaking the mercury in a barometer in the dark there was a glow from the vacuum in the top of the tube he assigned it to the presence of a mercurial phosphorus. Hauksbee, one of the best known electricians of that period, studied this phenomena at considerable length, and he showed himself a true forerunner of the electricians of our day, who would have us believe that all physics is but a branch of electricity, by assigning to the phosphorescence of the barometer tube an electrical origin.

There are two distinct kinds of phosphorescence, the phosphorescence of vital organisms; of glow worms, fire flies, jelly fish and the animalculæ that cause sea water to shine at night, and the phosphorescence of matter not imbued with life. The presence of light always indicates radiation, and radiation is a process involving the expenditure of energy. In the case of living organisms the energy thus expended may have its origin in the vital processes since an animal is a machine consuming fuel and transforming the energy thus obtained into various forms. In other cases radiation is due to motions of the particles of a body derived from energy received from without or to setting free of energy stored when the body was formed. The usual type of visible radiation, known as *incandescence,* is common to all bodies when heated above a certain temperature, the red heat. It is a definite function of the temperature and is produced by one stimulus only—heat, which sets up the necessary motions of the particles. The emission of luminous radiation due to any other stimulus is termed *luminescence.* It may occur at any temperature; has been observed even in the case of bodies cooled by air,* and is known to accompany the

* See Dewar: Proc. Royal Soc. (5) p. 340.

incandescence of certain oxides, modifying the light of freshly ignited CaO, ZnO, etc.† It is variously known, according to the stimulus which produces it as:—

Photo-luminescence, produced by the action of light.

Tribo-luminescence, produced by friction.

Piezo-luminescence, produced by pressure.

Crystallo-luminescence, produced by the process of crystallization.

Chemi-luminescence, produced by chemical action.

Electro-luminescence, produced by electrical action.

Cathode-luminescence, produced by the action of cathode rays.

Radio-luminescence, produced by the action of obscure rays from the radio-active elements.

X-ray-luminescence, produced by the action of Roentgen rays.

Thermo-luminescence, produced by sudden changes of temperature.

Luminescence of a body observed during the time that the stimulus acts is called *fluorescence.* When the emission of light continues after the stimulus has ceased the phenomenon is called *phosphorescence.*

Why in many cases the luminescence of a substance ceases with the excitation or so soon thereafter as to be observable only by means of the phosphoroscope while in other instances the effect may last for minutes, hours, or even months is not as yet definitely known. Liquids are fluorescent but never phosphorescent, and the fluorescence of liquids is believed to be dependent upon the dissociation of a dissolved substance. It has indeed been shown by Buckingham* that the fluorescence of elec-

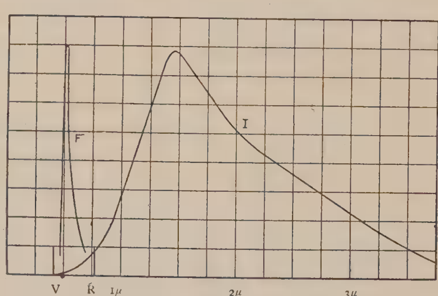

FIG. I.

trolytes increases in a definite manner with the dissociation.

In solids luminescence is supposed to occur only where the constitution is that of a solid solution and to be due to the presence in solution of traces of certain elements, such as copper, chromium, manganese, nickel, cobalt, lead and certain of the rare metals, such as cerium, lanthanum, yttrium, erbium, etc. The solvent may be a sulphide, such as CaS, which is used in the preparation of Balmain's paint, or ZnS, as in Sidot blende; a fluoride, such as CaF_2, or fluospar (from the luminescence of certain specimens of which as studied by Stokes the name fluorescence is derived); a silicate, as in willemite, etc.

The difference in the behavior of specimens of the same substance as regards the duration of the effect is very striking. One

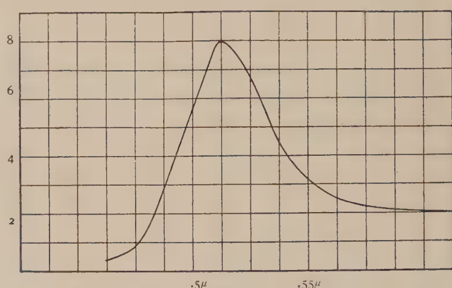

FIG. 2.

of two specimens of willemite, for example, the fluorescence of which when excited by the light from a spark-gap with iron terminals exhibit the same brilliant color will continue to glow for many minutes after the cessation of the stimulus while the light from the other disappears at once.

The character of the spectrum of luminescent substances differs from that of an incandescent body in several important respects. Both classes of spectra are continuous, but the range of the wave lengths represented in incandescence is far greater than in luminescence. In the case of incandescence the maximum of intensity, for any temperature which can be artificially produced, lies in the infra-red and the position of the maximum moves progressively from longer to shorter wave lengths through the spectrum in accordance with a definite law as the temperature rises.

In the case of luminescent bodies the maximum of intensity, so far as known, is always within the visible spectrum or in a few instances, possibly, in the ultra-violet, and its position is fixed as to wave length for a given substance and *independent of the intensity of excitation and of the character of the sitmulus.**

Fig. 1 affords a comparison between the energy curve of the spectrum of incandescent carbon at 1600° C. and that of the luminescence of fluorescein. In the for-

† Nichols and Snow: *Phil. Mag.* (5) Vol. XXXIII, p. 19.

* Buckingham: Zeitschrift für Physikalische Chemie, Vol. 14, p. 129.

* Nichols and Merritt: *Physical Review,* Vol. XIX, p. 18.

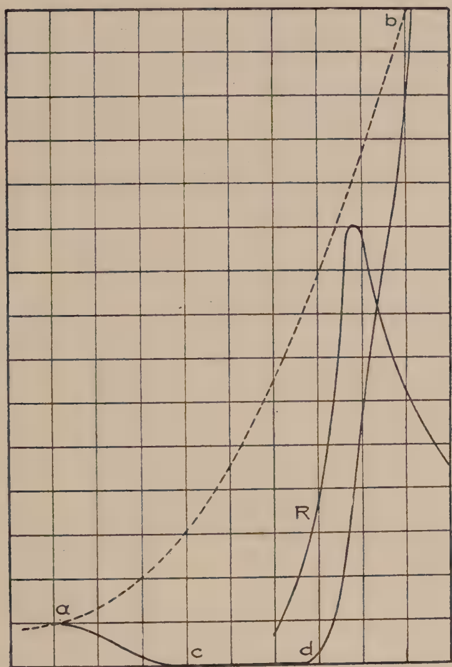

FIG. 3.

mer only the small part of the energy which is represented by the area enclosed by that portion of the curve which lies between the limits of the visible spectrum, V and R, is light-producing, whereas the entire spectrum of luminescence is comprised within those limits. The maximum of the incandescence spectrum is situated at about 147 μ, that of the luminescent spectrum at 0. 52 μ. Drawn in this way the curve for luminescence appears to indicate a narrow band, almost a line; but if we increase the scale of wave lengths twenty-fold, as in Fig. 2, we find the type of the luminescence curve to be very similar to the energy curve for incandescence. Each is characterized by a single sharply defined maximum and by a steeper slope towards the violet than on the side towards the longer wave lengths.

This resemblance is by no means confined to this particular case. The curves for the following substances are of the same type † and it is probably common to all luminescence spectra of solids and liquids.

FLUORESCENCE SPECTRA.

Fluorescein (in alcohol).
Eosin "
Naphthalin-roth "
Rhodamin "
Resorcin-blau "
Quinine sulphate (in water).
Chlorophyll (in alcohol).
Aesculin (in water).
Canary glass.
Sidot blende.

PHOSPHORESCENCE SPECTRA.

Cuban fire fly (measured by Langley).*
Numerous inorganic phosphorescent substances studied by Lenard and Klatt.†

The intensity of luminescence is always far too small to admit of the determination of the distribution of energy in the spectrum by direct measurement, but it is possible by means of the spectro-photometer to compare many such spectra with the spectrum of such source as the acetylene flame, the energy curve of which is known, and thus to be obtained the curve for the distribution of energy in the spectrum of the luminescent body. It is in this indirect way that the curves shown in Figs. 1 and 2 were determined. By using monochromatic light of various wave lengths for excitation we find that rays corresponding in wave length to the regions of absorption of the substance act as a stimulus whenever the wave length of the absorption band is less than that of the luminescent spectrum, and that absorbed light of greater wave lengths is inactive. The position of the spectrum of luminescence is determined by that of some absorption band nearly or not coincident with the luminescence spectrum, the maximum of the absorption band always lying slightly further towards the violet.

In Fig. 3, for example, the dotted line *ab*, is the energy curve of that portion of the spectrum of an acetylene flame which is included in the diagram. If a cell containing a certain solution of rhodamin be interposed in the path of the light from the flame we get the energy curve, *acdb*, for the transmitted light. In other words, the solution, which is nearly transparent at *a* and *b* becomes nearly opaque from *c* to *d* and the figure depicts an absorption band of this solution having a maximum (or minimum transmission) between *c* and *d*. Associated with this band is the fluorescence spectrum of rhodamin, the energy curve of which is shown (curve R). The maximum of fluorescence lies at 0.577 towards the red from the maximum of absorption.

In all the cases studied the absorption band and the luminescence spectrum overlap and all the wave lengths included in the absorption band are capable of producing excitation. Since the luminescence spectrum is independent of the character of the exciting light, the longest waves that may be used for excitation will produce a fluorescence spectrum, some of the

† Nichols and Merritt: *Physical Review*, Vol. XVIII, p. 403; XIX, p. 18; XXI, p. 247.

* Langley and Very: *Phil. Magazine* (5) XXX, p. 200.

† Lenard and Klatt: Drude's Annalen (15) pp. 225, 425, 633.

wave lengths of which are shorter than the wave length of the light used as a stimulus. The law of Stokes, who thought from his observations upon fluorite and some other substances, that the exciting light never exceeded in wave length the fluorescence which it was capable of producing, is not strictly true.

Many of the phenomena observed in the study of phosphorescence would lead one at first to suppose that the relation between phosphorescence and fluorescence could not be the simple one stated in a previous paragraph. In many instances the color of phosphorescence is seen to change as the light dies away. In other cases the fluorescence of a substance will present one color, and the phosphorescence another. When, for example, Sidot blende is excited by means of ultra-violet light or

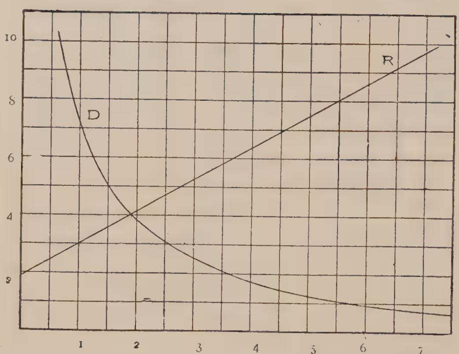

FIG. 4.

by the X-rays it exhibits a fine blue fluorescence which upon cessation of excitation changes to a green phosphorescence.* These phenomena are, however, capable of explanation from the fact established by Lenard and Klatt † and others that many substances have luminescence spectra containing two or more bands. It is probable that each band in such luminescence spectra is due to the presence in solution of a given metal. Where only one metal is dissolved we have a fluorescence spectrum consisting of a single band. Where two or more metals are present each one may produce independently its own band, giving a complex spectrum.

The rate of decadence of these bands, after excitation ceases, varies greatly and the color of phosphorescence therefore changes as the light dies away. In certain cases decay is so rapid that it is not possible to observe a color which is prominent in the fluorescence of the substance for any appreciable time after excitation has been interrupted. Since, moreover, each band is associated with a particular absorption band the fluorescence may vary greatly

* Nichols and Merritt: *Physical Review*, Vol. XXI, p. 247.
† Lenard and Klatt; l.c.

with the stimulus. In Sidot blende, the fluorescence spectrum of which consists of a brilliant green band and of one or more bands in the violet, we may produce a green fluorescence by the use of light in which the visible rays predominate, or blue fluorescence, by means of an ultra-violet stimulus or by the use of X-rays. Such stimuli excite the violet bands so powerfully that they dominate in the production of the color or fluorescence, but as soon as excitation ceases the violet component disappears, on account of its exceedingly rapid decadence, and the phosphorescent light, which persists, is green in color. The varying rate of decay of two bands may likewise serve to explain the change of color of phosphorescence as the effect dies away. The more fleeting of two bands may be the stronger, immediately after the cessation of excitation, but its domination over the color-tone of the light disappears with its decadence and the color goes over by insensible gradations to that characteristic of the other band, which, although weak at first, is more persistent.

There is another cause for apparent changes of color which affects all phosphorescence—the transition to the faint gray which follows any color sensation whatever as the intensity becomes too feeble to stimulate color vision. The rods of the retina according to the physiologists continue to be excited by these weaker rays and this sensation, which is independent of the wave length of the stimulus, is ill-defined colorless gray sometimes designated by the term *rod white*. This is the final retinal sensation received from the light of phosphorescence before extinction.

The law of the decadence with the time was carefully investigated by E. Becquerel, to whom our first systematic studies of phosphorescence are due. Becquerel found his observations to be approximately expressed by the exponential equation

$$I = I_0 e^{a t}$$

but subsequent measurements have shown that the decadence does not follow this simple law, and several attempts have been made to find an empirical equation which will represent the observed results. It is evident that in the case of substances having several bands in the phosphorescence spectrum, each of which differs in its ray of decay, the law of decadence for the light as a whole will be a complicated one. Since, however, as has been shown by Professor Merritt and the present writer,* the various wave lengths of a single band decay at the same rate, it should be possible from observations upon the light of such a band to determine the law.

The phosphorescence of Sidot blende affords favorable conditions for the study

* Nichols and Merritt.

of these phenomena since the violet bands are of very short duration while the brilliant phosphorescence of the green band is persistent. In some recent experiments on this substance it was found possible to observe a given wave length of the green phosphorescence band by means of the spectrophotometer and to record its intensity as a function of the time. The observations covered an interval of about twenty seconds from the cessation of excitation.

A study of the curves thus obtained showed that the decay of intensity was not exponential. If, however, we adopt the theory that the exciting light serves to dissociate the molecules of the luminescent substance, breaking them up into two electrically charged particles, and that luminescence is due to the recombination of these separated ions; and if we assume that the law of recombination is the same as that for ions in a gas, it is possible to derive an expression for the intensity of the light due to the collisions between the positive and negative ions. If the number of positive ions present in a unit of volume at any time be t and the number of collisions between a positive and a negative particle be proportional to the number of

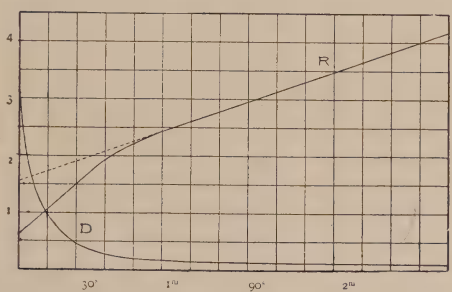

FIG. 5.

each present; and, if, finally, a certain proportion of the collisions produce a recombination of the ions with emission of light; we have

$$I = \frac{1}{(a + bt)^2}$$

where a and b are constants. The intensity I, according to this hypothesis, should be inversely proportional to the square of the time and a curve having times as abscissæ and the reciprocal of the square root of the intensities as ordinates should be a straight line. Our observations thus plotted were found to be in conformity with this hypothesis within the area of observation. In Fig. 4 one of these decadence curves (D) and the line of the reciprocals (R) is shown.

Knowing that the law of decadence for the various wave lengths of the green band is the same we then substituted for the spectrophotometer a Lummer - Brodhun photometer, one side of the screen of which was coated with Sidot blende. The photometer carriage was mounted in a fixed position at one end of a long photometer bar and a standard light of suitable intensity, consisitng of an acetylene flame carefully screened and viewed through an ap-

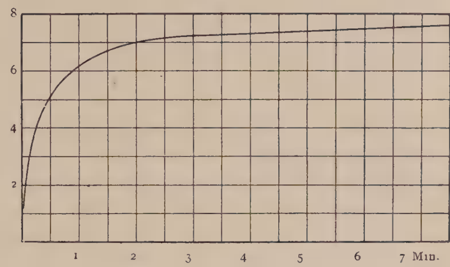

FIG. 6.

erture five mm. in diameter, was so mounted that it could be shifted to any desired position upon the bar.

A mercury arc lamp of the Lummer type served as an exciting source. The light from the mercury arc was passed through a color screen opaque to the green and yellow lines so that the exciting light consisted of those portions of the violet and ultra-violet spectrum capable of transmission through glass.

It was possible by this method to extend observations of the decadence curve of phosphorescence over the period of fifteen or twenty minutes or nearly 100 times as long as in the observation of monochromatic light with the spectrophotometer. The curves thus obtained, which were plotted in the manner already described with the square root of intensities as ordinates, exhibited a new and unexpected feature. Starting from the intercept the curves as before were straight for about ten seconds. They then turned more or less sharply downward, after which they again assumed the form of a straight line, but of different slope. It would appear therefore that in the decadence of the phosphorescence of this substance a rapid rate of decay is followed by another and slower decadence,

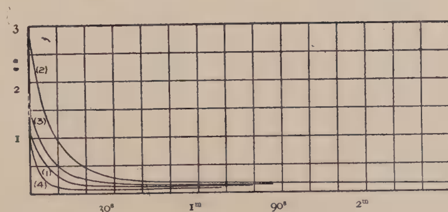

FIG. 7.

both of which follow the law that the intensity is inversely proportional to the square of the time. Fig. 5 shows a typical decadence curve (D) and the correspond-

ing curve (R) for the reciprocal of the square root of the intensity. The diagram covers an interval of only two and a half minutes. It refers to observations made after exposure of the Sidot blende screen for two minutes to the violet rays of the mercury lamp.

Experiments upon the decadence of the light emitted by a specimen of phosphorescent willemite gave results similar to those

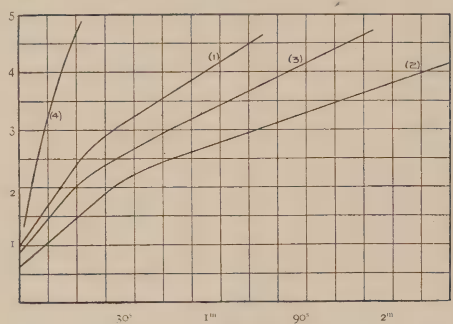

FIG. 8.

obtained with Sidot blende. The exciting source in these experiments was an electric spark between iron terminals and the luminescence immediately after the cessation of the spark discharge was quite as bright as in the case of Sidot blende. Decadence was, however, much more rapid; the interval during which measurements could be made extending only for about one minute. The curve for the reciprocal of the square root of the intensitv as a function of the time consists as before of two straight lines varying in slope. Similar results were obtained with Balmain paint and with a phosphorescent substance of unknown composition imported from Germany—the so-called *Emanations Körper* used in the study of radioactivity. Since many of the observations on the decay of phosphorescence made by Becquerel, when tested by plotting the reciprocal of the square roots, show the same character, it is probable that this is the general law of decadence for all substances.

The initial intensity of phosphorescence and the duration of the effect increase as the time during which a substance is exposed to light increases and continued exposure leads to a saturation such that further excitation is without effect. In Fig. 6 the initial phosphorescence of Sidot blende as function of the duration of exposure to the light of the mercury arc is shown. Complete saturation is not attained within the time limit of the diaphragm, but the approach to it is obvious. The curve also exhibits the same in which the fluorescence of this substance gradually increases during excitation. There is during this period a storage of energy by the freeing of ions and these recombining after exposure give us the phosphorescence. The decadence curve is, however, not the counterpart of the curve for the growth of luminescence, but the two related to one another in a manner curiously like that of the curve for the rise of induced electromotive force in an electric circuit and the decadence of e. m. f. when the circuit is broken. Compare in this direction Fig. 6 and curve D in Fig. 5.

The effect of excitation upon the luminescent substance is to produce a curious instability which may be likened to that of iron subjected to the action of the magnetic field. If Sidot blende which has rested for several days in the dark be exposed to light for a time inadequate to saturation, say ten seconds, the decadence curve will have the form of curve 1, Fig. 7. If it then be saturated the decadence observed will be represented by curve 2. If, now, it be exposed again, for the same interval of time as in the first instance, the decadence will be much slower in consequence of the previous saturation. (See curve 3.) There is a certain retentiveness of luminescence, and the effect of previous excitation to saturation shows itself for several hours. If, for example, the short excitation after saturation be delayed for several hours the substance will have drifted back into a condition more nearly like that in which it was after being in the dark for several days, but yet it will not have returned completely to the state attained after prolonged rest. As in the case of iron which has been magnetized and which loses its residual magnetism with time, a phosphorescent substance does

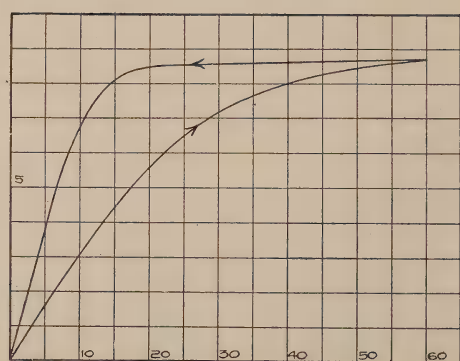

FIG. 9.

not return to complete neutrality in accordance with any regular law. That is to say, its condition, even after the three or four days is not always the same. Other influences besides that of time appear to affect the state of the substance. Five minutes' subjection to a temperature of 100° C. will, for example, have more effect than several hours of darkness. Red

and certain infra-red rays are still more effective. Light from an incandescent lamp after passing through ruby glass will in a few seconds change the condition of Sidot blende in such a manner that the decadence after ten seconds' exposure is much more rapid than is the case when the exposure is made after prolonged rest. (See curve 4 of Fig. 7.) Whether rest in the dark would ever bring the substance into the condition to which it comes within a few seconds under the influence of red light has not yet been determined. These effects the better seen in Fig. 8, in which the reciprocal of the square roots of these observations are plotted.

The phenomenon of retentiveness may be clearly exhibited by exposing a screen to red and then measuring the decadance after successive exposures to exciting light, each exposure being greater than the foregoing until the saturation is reached, after which a similar series of exposures each shorter than the foregoing is made. The curves for these shorter exposures after saturation do not correspond as to duration on account of the retentiveness of the substance, and if a curve be plotted, taking the reciprocal of the square root of the intensity in each case after a given interval of time, say three seconds, from the cessation of exposure with length of exposure as abscissæ, we get a curve analogous to a hysteresis curve for iron. (See Fig. 9.) The same phenomena as regards saturation and retentiveness are observed in the case of willemite, but the phenomena are less marked.

The effect of red and infra-red rays upon phosphorescence was first observed by Thomas Seebeck, the discoverer of thermo-electricity, whose observations were described by Goethe* in his "Farbenlehre." E. Becquerel,† and later his son, H. Becquerel,‡ made an extended study of this subject, and the latter used screens of phosphorescent material for the purpose of mapping the infra-red spectrum of the sun. J. W. Draper § in 1881 photographed the effect by submitting screens first to the action of the infra-red spectrum, after which a contact photograph from the surface was taken. Fromm ¶ made careful studies of the sun's spectrum by this method.

In 1904,|| Dahms studied the effect of different parts of the spectrum upon previously excited phosphorescent surfaces, such as Balmain's paint, strontium sulpnide with copper, zinc sulphide, and fluorspar. He found the action to be selective, not all wave lengths of the infra-red having the power to darken the phosphorescent surface. His photographs show an active region in the infra-red, followed in the case of Balmain's paint and zinc sulphide by a narrow inactive region. From the side towards the violet of this inactive band all wave lengths are effective in reducing the

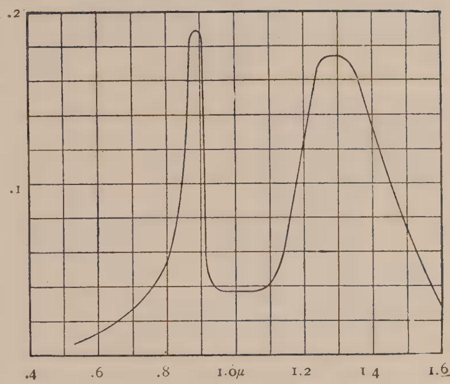

FIG. 10.

brightness of the surface until that portion of the spectrum is reached which is capable of producing phosphorescence. In certain cases, particularly that of Balmain's paint, a limited group of rays in the extreme violet were likewise found to have the power to darken the surface.

Sidot blende is more strongly affected than any other phosphorescent substances thus far studied, and it is easy by throwing upon a screen of this material, previously excited to phosphorescence, the spectrum from a source of light, such as the electric arc, to observe the phenomenon.

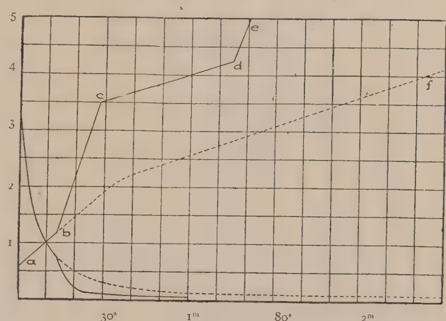

FIG. 11.

The calibration of Dahms' instrument did not extend to the infra-red and for the purpose of checking his results and of obtaining more definite information concerning the effect of this portion of the spectrum upon Sidot blende, Professor Merritt and the present writer have recently made measurements with the spectrophotometer upon the luminescent spectrum of this sub-

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* Goethe: Zur Fabenlehre III, p. 55.
† E. Becquerel' *Comptes Rendus* 14, p. 903; 77, p. 30; 83, p. 243; also *La Lumiére*, Vol. I. p. 32.
‡ H. Becquerel: *Ann. de Chim et Phys.* (5) 30, p. 1.
§ Draper, J. W.: *Phil. Mag.* (5), Vol. II, p. 160.
¶ Fomm: *Wied. Ann.* 40, p. 681.
|| Dahms: *Drude's Ann.*, 13, p. 425.

stance; comparing the brightness of the same when exposed to a given wave length of radiation from a Nernst filament, with the intensity of luminescence when not thus exposed. For this purpose a mirror spectrometer was set up with quartz prism and monochromatic rays varying in wave length from .8 μ to 1.6 μ were thrown upon the luminescent surface under observation. The effect became easily measurable at wave length .8 μ which even for this weak spectrum reduced the intensity of luminescence by 5 per cent. It rose rapidly to a maximum at .9 μ which was found to be the most active portion of the infra-red spectrum. The inactive band was located as lying between .93 μ and 1.1 μ, beyond which lies a second active region at 1.3 μ The results are shown graphically in Fig. 10.

When infra-red light is thrown upon a phosphorescent surface after excitation has ceased the effect manifests itself by an immediate change in the rate of decay. Upon the cessation of exposure to these rays the phosphorescent surface immediately returns to its original decadence, no after-effect of such exposure being apparent. Fig. 11 shows the decadence of a Sidot blende screen excited to saturation, then allowed to decay under normal conditions, 13 sec., at which time the light from an incandescent lamp behind ruby glass was thrown upon the screen for a few seconds, then removed and then thrown upon the screen again. The effect is best shown in the curve for the reciprocal of the square root of the intensities (*a, b, c, d, e*). The curve *a, b, f,* is the ordinary decadence curve.

Of the influence of temperature upon luminescence our knowledge is as yet fragmentary. We know in a general way that numerous organic substances, such as paraffine, stearine, albumen and ethyl alcohol, which are not appreciably luminescent at ordinary temperatures, become so when cooled to about —190° C. The most striking experiments of this description, which was devised by Dewar, consists in cooling an egg in liquid air, breaking it open and exposing the albumin to the light of the electric arc. The blue glow which surrounds the yolk is very brilliant and remains visible in the dark for several minutes. The yolk shows no luminescence.

Other forms of albumen were tested in the course of an investigation of the luminescence of organic substances at the temperature of liquid air.* These showed only a feeble yellow phosphorescence instead of the fine blue of the white of egg. It is probable that the luminescence of the latter substance is due to traces of some dissolved metal; the albumen being merely the solvent.

Certain substances, such as phthalic anhydride, antipyrin, salicylic acid, arsenious oxide, and benzoic acid show their most intense phosphorescene at temperatures somewhat above —190° C.*

Many phosphorescent substances, after exposure to light, glow for a time when suddenly heated. This phenomenon, *thermo-luminescence,* appears to be due to an unlocking of previously stored energy by heat. That there is no transfer of heat energy into the energy of luminescence is probable since the effect is temporary and since the glow cannot be obtained by subsequent heatings unless the substance be first subjected to its proper stimulus.

In this paper many aspects of the subject have been altogether ignored. To the extensive researches of Lenard and Klatt, who determined the type of phosphorescence produced by the solution of various metallic salts in a variety of solid solvents only the briefest reference has been made. The effect of fluorescence upon the absorption of light by the fluorescing substance, discovered by Burke † for canary glass and subsequently confirmed in the case of various organic liquids,‡ has not been considered nor has anything been said about the related phenomenon of the increase in electrolytic conductivity of solutions when excited to fluorescence.¶ Both effects, although experimentally established by the investigators cited, have since been sought for by Carmichael without success.

Other recent investigations, the discussion of which is beyond the limits, as to space, of the present paper, are those of Morse,|| who has shown that in addition to the usual continuous fluorescence spectrum certain specimens of fluorite under powerful illumination have well defined line spectra of fluorescence.

Radiation of this character from solids is altogether foreign to previous experience and no adequate explanation has as yet been found unless, indeed, the suggestion put forward by the author be substantiated, that the spectra have their origin in gases occluded within the crystals. This view finds support in the very remarkable fluorescence spectrum of sodium vapor described by Wood,* who has obtained, by varying the conditions of the experiment. in place of the fluorescence spectrum first observed by Wiedemann † a line spectrum of great complexity.

In luminescence we have one of the most important branches of the science of radiation. For many years it has been one of the most neglected branches of that science. Our knowledge of the phenomena is

* Nichols and Merritt: *Physical Review,* 18, p. 355.

* Nichols and Merritt: l.c.

† Burke: Phil. Trans. 191 (A) p. 87; Proc. Royal Soc., 30 III, 1905.

‡ Nichols and Merritt: *Physical Review,* XIX, p. 396.

¶ See Nichols and Merritt: l.c.

|| Morse: *Astrophysical Journal,* 21, p. 83.

* Wood. *Phil. Mag.* (6) 6 p. 362.

† Wiedemann: *Wiedemann's Annalen,* 57, p. 447.

far from complete and no satisfactory theory has as yet been established. The older and simpler views of the constitution of matter were indeed inadequate for such speculations, and it was impossible to form any definite conception of a plausible mechanism to account for the observed facts. With the new hypotheses of matter already developed to account for the phenomena of solution, electrolysis, disassociation and radioactivity at our service, this difficulty no longer exists. We can now imagine various intramolecular processes to account for isolated facts and even groups of facts of luminescence and suggestions looking to a theory have been formulated by Wiedemann and Schmidt, Voigt and others. A vast amount of quantitative work, however, remains to be done before anything like a complete theory is likely to be presented, or, if presented, can possibly be confirmed in all its details. Theory building in such a field as this will inevitably lead physicists to further insight into the nature of matter and thus ultimately to practical applications in a department of physics which at present appears to be of purely scientific interest.

THE PRESENT CONDITION OF INCANDESCENT GAS LIGHTING

By Prof. Dreschmidt, Berlin.

Read before the Annual Meeting of the German Gas & Water Engineers, 1906.

Translated for The Illuminating Engineer from the *Journal für Gasbeleuchtung.*

Last year I discussed a promising improvement in gas illumination, the inverted incandescent gas light, and stated that I would make further announcements of its progress, especially as applied to the illumination of streets and public squares. But the effiiciency of this light does not depend on the burners alone, but to an equal degree on the character of the incandescent mantles; and you will therefore welcome a few statements on manufacture of improved incandescent mantles.

In the beginning a fabric knitted from the so-called Hauschild yarn was used as support for the luminous substance in mantles. These mantles lost their shape by use, and hence their power of illumination decreased rapidly and considerably. The Ramie mantle, introduced by Buhlemann in 1898, had this fault to a less degree, so that cotton is less used at the present time. But both kinds still had the fault of decreasing illuminating power, and were too easily broken. To obviate these difficulties I believe that mantles made of artificial silk are very suitable, some of which I shall introduce to you.

Knofler endeavored as early as 1894 to make use of a web from artificial thread. He added the necessary salts to the colodion solution that served to make the thread, according to Chardonnet's process, and transformed the salts into oxides by treating them with alkalies. But the manufacture of such mantles by this process met with technical difficulties, as well as too high a cost of production, and could therefore not be used. Plaissetty finally succeeded in manufacturing good mantles from artificial silk thread. He first impregnated his fabric in the same way that the cotton or Ramie fiber was impregnated, with the proper solution or rare metal salts. It would naturally be supposed that this artificial thread could not be as easily impregnated, because it does not have the pores of the natural fibers; but strange to say it absorbs much more of the impregnating substance, so that only 1-3 as much weight of this thread is required to support the same mass of oxide of the rare earths as with cotton or Ramie thread. This equalizes the price of the artificial silk thread with that of Ramie or cotton. For instance, a mantle made of artificial silk weighing about 1.7 g. before it was burned left 0.6 g. of oxide as ashes, while the cotton thread with about the same amount of oxide had a weight of about 4 g.

If such an impregnated and dried artificial silk mantle is burned to ashes directly, as is generally done with the mantles now in use, it falls to pieces. Plaissetty succeeded in avoiding this by making the soluble salts of the oxides of the rare earths insoluble by treating them with ammonia, and then burning out the fiber. In this way we get a skeleton of oxides that, though soft and very flexible when compared with a cotton or Ramie mantle, is still much more solid than the latter. This may easily be seen by pulling at these mantles when suspended from a hook. Tests with the shaking apparatus give results showing the enormous difference in strength between the old and new forms of mantles after they had burned for a short time, as well as after a longer period. Favorable results were also obtained with respect to maintenance of illumination, although different kinds of silks gave different results.

The intensity was measured with a consumption of 120-121 liters of gas per hour at a measure of 40mm. Their strength was tested on the shaking apparatus, and was measured by the number of shocks that the mantles withstood before they began to show signs of injury. Most mantles split lengthwise after the number of percussions recorded, except when they were too large in diameter they rubbed through just above the head of the burner; not once did a breaking of the web in the centre, or a tearing off of the head occur, as was so frequent with the old ones. It is also pe-

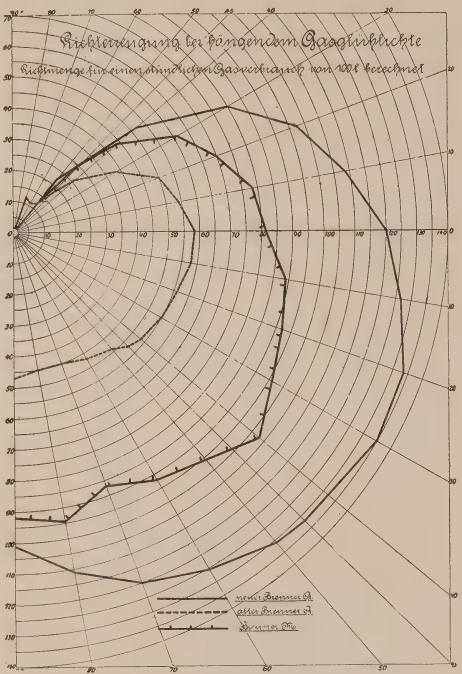


FIG. 1.

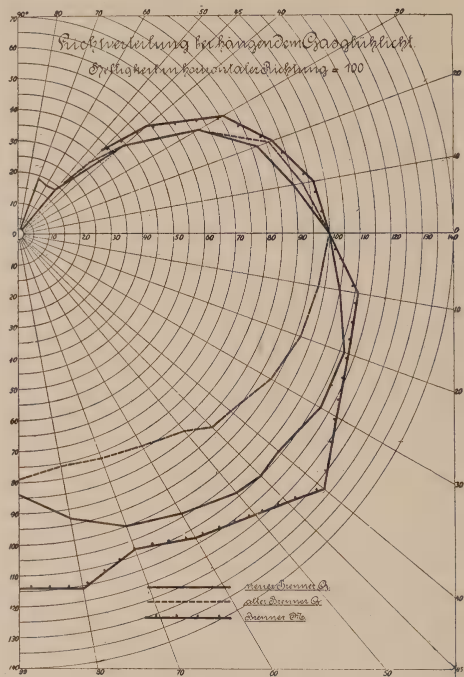


FIG. 2.

culiar that small holes in the web have no effect on its solidity, as they do not grow larger or cause its falling to pieces.

The different kinds of artificial silks do not give the same effect with regard to power of luminosity and solidity. The luminosity is not especially high, but satisfactory; and it is expected to increase when their production takes place on a large scale, and with better care. The results show that the luminosity in case of the Oberbruch silk increases steadily within 1000 hours of burning, is nearly uniform in case of the Chardonnet silk, while denser silk gives a considerable decrease. As regards strength the results are similar, the silk mantles far excelling those used at the present time. The latter can only withstand about 100 percussions on the shaking apparatus, and often 20 to 50, or even less than that.

The differences mentioned,—the greater durability and more uniform maintenance of light, must be owing to the original structure of the artificial silk thread, and to the peculiar character of the luminous substances in it. The skeleton thread of the new incandescent mantles looks like a bundle of twisted wires, while that of the old form appears as if it consisted of innumerable small fibers. The ashes of the first feels sandy to the touch, while that of the latter soft, like flour, causing the separate particles to adhere more closely to each other; this evidently is the main reason for their greater strength.

It has always been thought best for the production of light that the raw mantles should contain the rare earths in the form of nitrates, because they puff up greatly when burned, and leave a foamy, voluminous oxide, that has a large area of illuminating surface. The new incandescent mantles, however, contain originally hydroxides, which do not puff up during incineration, have no such large area, and therefore a high luminosity might not be expected; but our old opinions do not hold true. The maintenance of luminosity is owing to the fact that the threads are not foamy and fibrous, but compact and unchangeable in form while in use.

Because the luminous substance exists in the Plaissetty mantle as an hydroxide another advantage is effected; they are not hygroscopic, and can be kept, unlike the old ones, for a long time without changing their quality.

But owing to the peculiar structure a different method of burning off and forming them is required. It is not possible to transform them into ashes and afterwards form and harden them as in the case of the old mantles, because the web, i. e. the support of the luminous substance, is not easily burned up on account of the nitrates being absent. The Plaissetty mantles do not need to be coated, and without having

been first burned to ashes is pulled over a compressed gas burner, the diameter of which is the same as that of the crown of the incandescent burner, when the compressed air is ignited, the pressure being much less than that used in the hardening process of the old mantles. It does not answer to move the mantle up and down by hand over the compressed gas burner, as in the old process, it must be moved upward gradually by a special device, and exactly perpendicularly as the process of burning proceeds. The method of burning which Plaissetty himself undertook was troublesome, requiring much attention and skill. But I have seen lately that, by using a higher gas pressure than Plaissetty's, the whole operation becomes simple, and requires no special skill. The new mantle therefore is much better suited to burning off by machine than the old form.

Up to the present time the Plaissetty mantle has been used in small quantities in a few places only, for instance in Paris, Mailand, and Copenhagen; in Germany it has not been used much. But recently the Cerofirm Company of Berlin has bought the Plaissetty patent and process, and the company is preparing to produce it on a large scale in the near future. Let us hope that the company will be successful, as well for its own profit as that of incandescent gas illumination.

So far, no Plaissetty mantles have been made for inverted burners. It is comparatively difficult to give them the proper shape, and more so in the case of the artificial silk, but it seems probable that this will be overcome.

I shall now take up the inverted incandescent gas burner. At the last annual convention I implied that it means a decided improvement over the upright burner in regard to the light obtained from a certain quanity of gas, as well as in the more advantageous distribution of the light produced. I said then that it consumes about half as much gas as the upright one for the same mean lower hemispherical candle power, and that therefore it is much more economical than the old kind. In the meantime a burner has been brought upon the market that gives much more favorable results than the best known at that time. As may be seen from the samples its shape is a pleasing one, and it has the advantage of being furnished below with a globe of glass without perforations, and therefore of being less sensitive to draughts of air. It looks almost like the Nernst electric lamp.

The new G burner with clear glass globe uses only 0.78 liters of gas for 1 hefner candle lower hemispherical intensity; the old G burner 1.88 lit.; the best old inverted M burner, 1.08; and the upright Welsbach burner, bare, 2.01, and with reflector 1.89. These figures show clearly what progress in economy the inverted burner has made within a short time, and how greatly superior it is to the upright burner. This is very conspicuously shown by the curve, Fig. 1, showing the intensity in the different directions from the old G—, the M—, and the new G-burners, with a consumption of 100 liters given in Fig. 2, in which the horizontal intensities are represented by 100, shows that the new G burner gives the most advantageous distribution, and better in the M-burner. The vertical intensity of the first two is less than in the horizontal direction, and at 30 degrees below the horizontal. This is especially important because it is chiefly concerned, since the horizontal intensity is greater than the vertical, and since the latter in this case is sufficient even to satisfy the demands of a good illumination for open spaces.

Though the two advantages mentioned, of the greater economy and more advantageous distribution of light cannot be denied, the introduction of the inverted burner will yet encounter difficulties. Many complaints are heard, partly justified and partly not. They are justified to the extent that, besides the good burners, very imperfect ones are frequently sold, which give out objectionable odors and which rapidly injure the mantle on account of the gases.

I have already pointed out that the bad odor is caused by imperfect combustion, and that this is caused by the improper mixture of the gases; the latter is also very often the cause of a rapid injury to the mantles which are surrounded by the destructive gases. And it must not be forgotten that the mantles also suffer, though in a lesser degree, from the conduction of heat from the burners; and it is therefore absolutely necessary to put non-conducting insulators between burner and mantle to prevent this conduction of heat. But those complaints are unjustified which result from a careless treatment of good burners, or a disregard of their peculiarities. Complaints in most cases are the fault of the manufacturer himself and of those who install and adjust them, because they do not instruct the consumer sufficiently, or because they do not properly install them. For instance, a certain minimum gas pressure is required for a good burner, which varies according to the kind of burner between 20 and 30mm.

But some burners are also sensitive to too high a pressure under which they give an unsteady and flickering light. The latter fault may generally be removed by regulating the air supply by means of the shutter. Many complaints are also heard of the greater number of mantles required, although it is my experience that no more are needed than for upright burners. Breakage is often because of careless lighting too long after turning on the gas, which is then accompanied by a rather violent explosion. But this may also be caused by

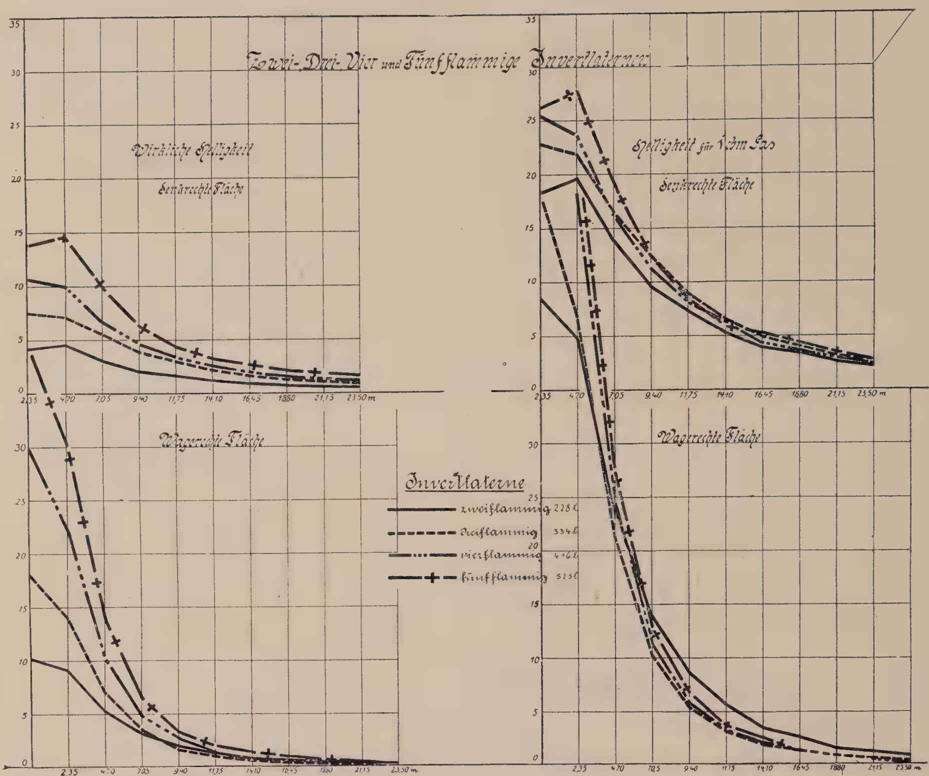


FIG. 3.

a bad construction of the burner. Especially in larger stores where there are many burners much harm is done in this way. To prevent this it is desirable to furnish the burners with special pilot flames, or igniters, that cause an ignition at the right time. Most burners do not have these arrangements, or if present they are faulty. It should be remarked that pilot flames are an expensive method of lighting, though they contribute to the protection of the mantles; but I do not think it advisable, from my experience to substitute automatic igniters for them because there are not quite to be depended upon, and do not ignite quickly enough. An igniter which may overcome these defects is due to the invention of Auer von Welsbach, with respect to pyrophorous alloy. He has found that an alloy of 30% iron and 70% Zirconium is strongly pyrophorous, and that it gives innumerable sparks of a high power of ignition on being only slightly rubbed with a file or any hard surface. Such an igniter, designed only for upright burners, has been used for several months in the laboratory of the Municipal Gas Works, and has worked well. By properly designing it, it is expected that such an igniter may also be used for inverted burners.

Finally I must again point out that the kind of mantle used has an important bearing on the maximum intensity obtained. Since we have different kinds of burners, but no standard burner, the mantles have to be fitted exactly to the burners with regard to width, length, shape, thickness of the thread, and kind of web. The mantles that are delivered by the different mantle manufacturers for the same kind of burner are very different in quality.

I shall now take up the application of the inverted burner to street illumination. Last year I stated that trials of this kind were being made in Berlin. Attempts were first made to place the burners in suitable lanterns, then in use which throw no shadow downward. But it was soon found that this was not profitable. There was, for instance, a diminution of intensity, or there were technical difficulties in the placing of several burners in one lantern. It was required that lanterns and burners should form, so to speak, an organic whole. Of such lamps those made by Ehrich and Graetz, and by the German Incandescent Gas Light Co., were chosen for illumination of Invalid street, in Berlin; they are closed below by a glass hemisphere, and are suspended from the top. Since these lanterns give a small-

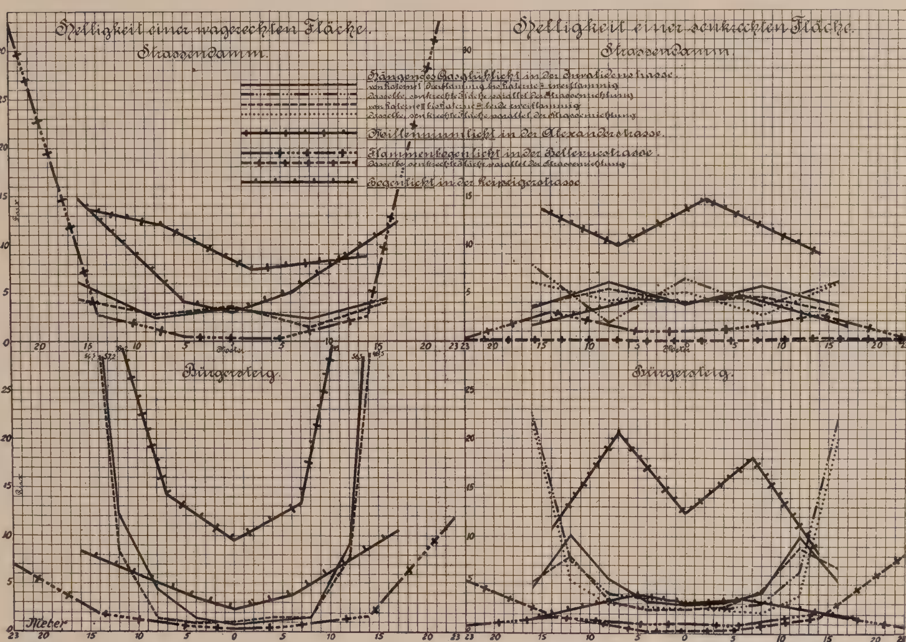


FIG. 4.

er sidewise distribution of light than those with upright burners, and since they naturally throw sufficient light downward, a reflctor must not be convex, but slightly concave, in order to direct the light that falls downward further outward. The mantles, especially in the case of lamps with several flames, are best surrounded by a more or less long glass cylinder open below for the purpose of admitting air to the seperate flames, and for the protection of the mantles in replacing them.

Since it was intended to obtain a much better illumination in Invalid street than could have been possible with two-flame lanterns with upright burners, lanterns with several burners were applied. It was to be determined what number of burners in the lanterns would be most advantageous. Two, three, four, and five burner lanterns were tried. The results are shown in Fig. 3 first with respect to the actual illumination obtained, and then for that form 1 cm. of gas.

The height of the source of light is taken as 4.7 m. The illumination was measured on a plane at different distances, both horizontally and normal to the rays. It may be seen that in the latter case at the same distance from the lamp, the illumination does not increase in proportion to the number of burners, and much less in the first. The two burner lantern surpasses here the one with three burners. The illumination of the horizontal plane, referred to a gas consumption of 1 cbm., per hour, at a distance of 7 m. is even greater from the two burner lantern than from the three burner. The efficiency is lessened by the fact that the single mantles obstructing each other in their radiation. If, therefore, we have to do with illumination of streets where the lanterns are placed at greater distances from each other the two burner lantern is to be preferred; at street crossing, however, where very good illumination is required for the sake of traffic, and where the distances from each other are not great, it is best to use three and four burner lanterns. This principal has also been followed in illuminating Invalid street. Each lamppost has two lanterns suspended on two straight arms running in the direction of the street. The height of the source of light above the pavement of the street is 4.5 m.

According to general opinion the illumination of Invalid street is very successful; and I think that the photometric measurements taken there confirm this opinion. The results are shown in Fig. 4. For comparison other results are also given that were found from former measurement in other streets of Berlin with different kinds of illumination. For instance are: in Alexander street, where the lanterns contain two compressed gas burners, each with a gas consumption of 1.2 cbm. per hour; in Leipziger street, with electric arc light in the centre of the street; and in Bellevue street, with flaming arc lamps, likewise in the centre of the street.

The illumination of the horizontal plane in the centre of the street in Invalid street is very evenly distributed—more so than that in Leipziger street with arc light illumination, though itself more feeble than the latter. In the same way the illumination on the sidewalk in most places is more feeble than in Leipziger street. The flaming arc light gives on the average more feeble illumination than the inverted gas burner, and the Millenium light surpasses all the three mentioned kinds of illumination. But we get an entirely different result if we consider the illumination on a perpendicular plane across the middle of the street in the different streets. The arc light still more, while the Millenium light has a much stronger effect than the other kinds of illumination. The illumination on a perpendicular plane running in the direction of the street and in its centre is, in the case of the flaming arc light, almost zero. The same conditions must exist in Leipziger street, since there, as also in Bellevue street, the lamps are suspended over the centre of the street.

But a decisive comparison of the value of the different kinds of illumination can only be drawn if we compare the cost as well as the illumination produced.

Let us consider first incandescent gas illumination, that is to say, intensive illumination with inverted and Millenium burners with which we are chiefly concerned. Putting the results obtained in the two streets mentioned, on a basis of 1 cbm. gas consumed, gives the curve, Fig. 5. Hence we obtain from the same consumption of gas on the average a better illumination on the perpendicular horizontal planes by the inverted incandescent burner. Probably the results for the inverted burner would be still more favorable if the lamps had only one single large burner, with the same gas consumption, in place of the three burners. But this can be done by using compressed gas. But not a single such lamp that burns with pure gas is known to me, though many are working at it zealously. The difficulties are greater than are generally supposed, though the construction appears simple because it is much easier to give a good downward movement to gas under a high pressure than under a low pressure. Only the Selas Light Company makes one large lamp.

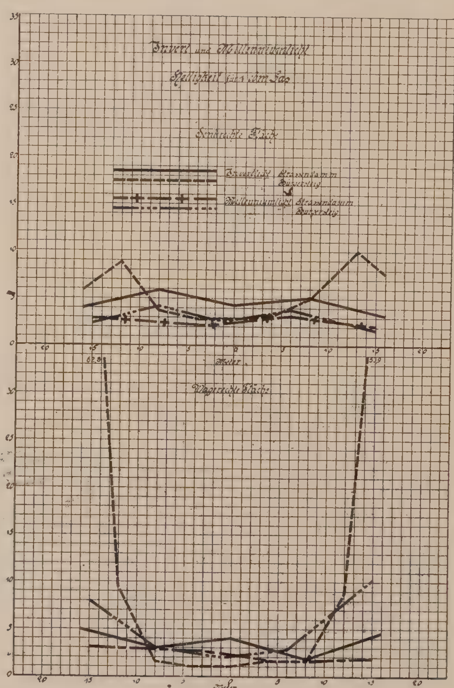


FIG. 5.

The Commercial Engineering of Illumination

SOME NOTES ON HIGH EFFICIENCY UNITS BY THE MANUFACTURER

By Max Harris.

Read before the Ohio Electric Light Association at its Twelfth Annual Convention, held at Put-in-Bay, Ohio, August 22, 23 and 24, 1906.

In view of the many technical and semi-technical papers which have been read on the subject of the Nernst System, this paper was written in the belief that you would be interested in hearing what may be termed a résumé of these papers, as expressing the belief and views of the manufacturer. Starting with a brief description of the article itself, and describing some methods of marketing, the demand for the article by the consumer is then taken up, and finally some notes on the value and utility of the lamps to the Central Station are presented.

THE ARTICLE ITSELF.

So much has been written and said about the Nernst System from the technical standpoint that no attempt will be made to cover this side of the question. While I appreciate fully the necessity and value of photometric curves and technical data for assisting the engineer in planning the lighting of large areas, and while all such data is available, and papers on this side of the question have been read before this association, I am of the opinion that for the daily problems which you have to solve in your efforts to increase the sale of electric current, and in meeting the requirements of your customers, that a full knowledge of the practical results obtained will be of greater interest and value to you.

The Nernst System, as now marketed, consists of five units for use on alternating current circuits of 110 or 220 volts, 25 to 133 cycles, for indoor and outdoor service, and popularly termed one-glower, two-glower, three-glower, four-glower and six-glower lamps.

The manufacturer, after four years of practical experience in the installation of these units, has been enabled, for all practical purposes, to classify these units as compared with other systems on the market as follows:

The one-glower lamp, consuming 88 watts at 220 volts, will successfully replace three 16-cp. incandescent lamps, or one gas mantle.

The two-glower lamp, consuming 176 watts at 220 volts, will successfully replace seven 16-cp. incandescent lamps.

The three-glower lamp, consuming 264 watts at 220 volts, will successfully replace ten 16 cp. incandescent lamps, or one four-burner gas arc.

The four-glower lamp, consuming 352 watts at 220 volts, will successfully replace fourteen 16-cp. incandescent lamps, or one 6-ampere A. C. enclosed arc lamp.

The six-glower lamp, consuming 528 watts at 220 volts, will successfully replace twenty 16-cp. incandescent lamps, or one 7½-ampere A. C. arc lamp, or one 5-ampere D. C. arc lamp.

The light emitted from the Nernst glower is absolutely steady at all times, mellow and pleasing, and of a color best suited for the illumination of stores, public buildings, and generally for all classes of indoor illumination.

An important and valuable feature, not possessed by any other system, is the absolute uniformity of quality and color from the various units. Until the advent of this system, it was impossible to obtain such results, and it is only necessary to cite the example of window display and interior store lighting to forcibly impress upon you the importance of this feature of the Nernst System.

The flexibility of this system is such that units of proper size may be installed at existing outlets, avoiding the expense of rewiring, and what is more important, excessive or insufficient illumination at any point, insuring the consumer a cost for his illumination commensurate with his requirements.

The care and maintenance of the lamps is simple and inexpensive, as the experience of hundreds of Central Stations has demonstrated. Depending upon local conditions, labor cost and the number of units in service, the cost of maintenance ranges from three to eight mills per kilowatt hour.

METHODS OF MARKETING.

When the Nernst System was first presented to the public it was with the belief on the part of the manufacturer that such a system was needed, as with the then-prevailing incandescent system units of varying sizes, particularly the medium and larger sizes as represented by the three, four and six-glower Nernst units, were not available, and I do not think it necessary to attempt to satisfy you that the A. C. multiple enclosed arc lamp was and is an undesirable unit both from the operative and commercial standpoint, and was only employed because nothing better was available.

To successfully market any article there must exist a field for it, and this field must be developed by the manufacturer. Believing that such a field existed, and that the Nernst Lamp possessed points of superiority as above outlined, the manufacturer undertook to market the Nernst System.

Several methods of marketing were and are open to the manufacturer—through the jobber, supply dealer and contractor; through the Central Station, or directly to the consumer.

Up to the present time it has been found most satisfactory to market the Nernst System through and with the co-operation of the Central Station, and accordingly the policy of offering Central Stations a comprehensive and practical means of obtaining the desired results was adopted.

It has been my experience that in many instances the managers of Central Stations have looked with disfavor or alarm upon the advent of the Nernst System, expressing the belief that the introduction of Nernst lamps would tend to reduce their revenue, but I have yet to find a Central Station that has reduced its revenue because it adopted the Nernst System as one of the mediums through which to sell current. On the other hand, the Central Stations have been able to increase their business, maintain rates, obtain a volume of business not theretofore obtainable, and in general to increase the standard of illumination.

The basis upon which Central Stations should and do promote the use of Nernst lamps depends upon local conditions and the policy of the Central Stations.

The manufacturer rightfully expects that this system shall be offered to the consumer on an equal basis with other illuminants. This being recognized as a reasonable and just position, it has been the policy of the Central Stations, who have already established the precedent of loaning apparatus, to also loan Nernst lamps as an inducement for the use of current. Such a method is specially warranted with the Nernst System, aside from any established policy of the Central Stations, in view of the remarkable record made by this system in obtaining business not already enjoyed by the Central Station.

Other methods include a re-sale of the lamps at cost; in many cases under deferred payment plan, and in some cases on a rental basis.

Wherever the policy of free renewals is in vogue, free maintenance of the lamps has been adopted. In some cases where consumers purchase renewals for incandescent and arc lamps, a fixed charge, usually 10c. per glower per month, is made for the care and maintenance of Nernst lamps, or, inasmuch as the cost of maintenance is proportional to the wattage consumed, an additional charge of one-half cent per kilowatt hour is sometimes added to the regular rate for current.

After all, the question of the method to be adopted is a simple problem in arithmetic. As an example, a lamp costing $12.00 would carry an interest and depreciation charge of $1.80 per year, or 15c. per month, which charge may readily be included in the charge for current, and every Central Station manager can work out for himself a profitable method.

THE DEMAND FOR THE ARTICLE BY THE CONSUMER.

The demand for any article is based, first, upon its merit, and second, upon the publicity given the article and its advantages.

It is a well-known fact that the use of or adoption of any device which will tend to lessen the cost of a commodity, be it electric current or otherwise, will, and does, result in the greater use of that commodity. In other words, to lessen the cost per unit of illumination will increase the number of units in use.

The manufacturer, recognizing this truth as applied to the Nernst System, has assumed the responsibility of educating the user of artificial illumination to the advantages of this system and effectively promoting its introduction.

Much has already been accomplished along these lines, and now that the value of the Nernst System has been clearly demonstrated and generally admitted by the Central Stations, the manufacturer, through various mediums and methods of publicity, and in co-operation with and for the benefit of the Central Stations, will endeavor to create a still greater demand by a direct approach to the consumer.

As the consumer has a right to expect that the Central Station will furnish the best and most efficient illuminant, any Central Station whose conditions do not preclude the use of such apparatus, and which fails to meet this reasonable expectation and demand of its patrons, stands convicted of being an unprogressive and illiberal public utility. The duty of the manufacturer ceases after the demand has been created, and thereafter the responsibility rests with the Central Stations.

VALUE AND UTILITY TO THE CENTRAL STATIONS.

Some of the advantages accruing to the Central Station by the use of the Nernst System will be briefly set forth.

After all, the most important advantage is its ability to obtain and hold new business not already enjoyed by the Central Station.

The following extracts from the *Electrical World* of February 24th and April 21st are interesting as conclusive evidence of this contention.

"From all over the country come reports of the successful meeting by Nernst lamps of the stiff competition put up by so-called gas 'arcs' for commercial lighting. That the competition of this type of gas burner with electric illuminants is severe in the majority of cases cannot be denied, and it has perhaps been most keenly felt where the gas 'arc' has come into direct competition with alternating current arcs. As is

well known, both of these sources are deficient with respect to the proportion of total light thrown downward at angles below 60 degrees from the vertical. It is just at this point where the Nernst lamp comes in with its great percentage of downward illumination. That the gas burner does make a good showing when comparisons are made on the basis of mean spherical candle-power cannot be denied, but the defect noted has been its undoing, except where electric rates are very high and gas rates very low, when brought into competition with Nernst or high efficiency incandescent lighting units properly placed and equipped with reflectors. It appears to be the general experience that one three-glower Nernst lamp taking 264 watts is able to in commercial practice replace the ordinary four-burner gas 'arc' lamps; and this is confirmed by some recent tests which show that the useful light from a three-glower Nernst is about the same as that from a four-burner gas 'arc.' Assuming the Nernst lamp to be supplied with electrical energy at 10 cents per kilowatt hour, the cost of the three-glower, 264 watt Nernst lamp would be 2.6 cents per hour. Four-burner gas lamps, when burning at an efficiency making them comparable with the three-glower Nernst lamps, consume in the neighborhood of 20 cubic feet of gas per hour. With gas at $1.25 per thousand cubic feet, the cost would be 2.5 cents per hour. With the cost to the user approximately the same, the electric light naturally has always the preference.

"One of the most notable instances of the successful employment of Nernst lamps to win over the shopkeepers of a small city to the cause of electric lighting has been at Yonkers. Gas here sells at $1.00 per thousand cubic feet, but so successfully has the electric light company pushed the Nernst lamp, that gas and gasoline arc lamps have almost disappeared.

Many shops, although still equipped with ordinary Welsbach mantle gas lamps and gas arc lamps, use the Nernst lamp in preference. The company supplies the Nernst lamp free of charge and looks after its maintenance, with the result that the lighting business has grown enormously. On June 1, 1905, the number of Nernst lamps installed were as follows: 196 one-glower lamps, 382 three-glower lamps and 13 six-glower lamps, a total of 591 lamps with 1,420 glowers. The growth since then may be gauged from the number in use on March 1st of this year, which is as follows: 638 one-glower lamps, 571 three-glower lamps and 10 six-glower lamps, a total of 1,219 lamps with 2,411 glowers, making an increase of over 100 per cent. in the number of lamps connected in nine months."

Another advantage of the system is its ability to hold customers who are dissatisfied because of insufficient illumination or high cost. It has been the writer's experience with this class of consumers that what they most desire is better and increased illumination without material increase in cost. This can invariably be accomplished by the installation of a sufficient number of units of proper size.

Again, in the case of so many merchants who are using electricity for lighting their window displays and gas arcs for interior illumination, by cutting down some of the current consumed for the window display illumination and replacing the gas arcs by a complete Nernst installation, the consumer, at about an equal cost for a complete electric installation, replacing the former gas and electric outfit, is secured for the Central Station, with dual advantages to the Central Station of an increased sale of current and a load which instead of being an entirely peak and after peak load, becomes a distributed load, with part of it in use during the day hours.

The cut on page 6 illustrates the card used in some cities by the solicitors for reporting mixed installations to the Contract Agent of the Central Stations to enable them to pass upon the desirability of installing Nernst lamps. In this particular instance the consumer was using 12 incandescent lamps for window display lighting and four gas arcs for interior illumination. The proposed new installation would include two two-glower lamps in the windows and four three-glower lamps for the interior, showing an increase from a connected load of approximately 600 watts to a connected load of approximately 1,400 watts.

Again, the installation of four three-glower lamps instead of two arcs will invariably result in an increased use of electric current, as during the early morning and evening hours, when the use of two arc lamps is too expensive for the average small merchant, such users will operate two of the three-glower lamps.

In many cases on record Central Stations have changed their flat rate to meter rate contracts by installing Nernst lamps, and it requires no lengthy argument to convince you that in all such instances it is the proper move to install lamps of the highest efficiency available.

Where a Central Station changes from open arc service, it is advantageous to employ Nernst units of varying sizes, and particularly is this so where the use of alternating current multiple arc lamps is contemplated, because of the unity power factor of the Nernst System and its other advantages.

As a means of presenting something new and novel to the prospective consumer, the first installations of such lamps, because of the distinctive form of the lamp and the color of its light, will attract attention; attention will arouse interest, which in turn

will create inquiry, and inquiries, if properly followed, will result in the further introduction of lamps with a consequent increased sale of current, and with the further advantage that each lamp installed will shine out as an advertisement for the Central Station.

As a means of obtaining a large volume of business which may be classed under the heading of "Advertising," such as Window Display Illumination.

As a means of broadening the peak, due to the ability of the Central Station to obtain a large number of small consumers, who, as a rule, have a connected load very nearly equal to their daily-peak consumption, and which class of consumers are better than a small number of so-called large consumers, who, as a rule, have a connected load greater than their usual daily-peak consumption.

Another advantage lies in the fact that while Central Stations have been trying "to sell current at the meter," they now generally recognize they must go further and act as Illuminating Engineers, and accordingly become more interested in actually selling illumination. With the Nernst System this problem is made easier for the Central Station by reason of its many advantages—quality of light, efficiency, appearance and flexibility of the system.

In conclusion, your attention is directed to the recent development of a series system of single vertical glower Nernst lamps for street lighting. Briefly, the system consists of placing in circuit on any alternating constant current circuit of 6.6 or 7.5 amperes a series transformer with each single glower lamp. The total wattage consumed by the series transformer and lamp is 115 watts. By the use of this system Central Stations are placed in a position to compete with the single burner Welsbach gas system.

ORGANIZATION AND CONDUCT OF A NEW BUSINESS DEPARTMENT SUITABLE FOR CENTRAL STATIONS IN CITIES OF 50,000 POPULATION AND UNDER

By Charles Nathan Jackson.

I have always lived in the small city of "C.," a town of about thirty thousand inhabitants, in Central Ohio. I have been in the banking business for several years, and was interested, to a certain extent, in our local electric light plant. In the course of time, however, I purchased the entire property. The former officers of the company had always been satisfied to let well enough alone, and, as the plant was paying a small dividend, they were not very aggressive. I determined to see if, by increasing the business, I could increase the net earnings of the property.

We had a total generating capacity of 600 kw. and did not do the municipal lighting. The revenue was about thirty thousand dollars per year, and the plant was loaded to its utmost capacity about five o'clock in the December afternoons. The manager in charge was a very capable operating man and had several years of experience at operating plants. He was drawing a salary of two thousand dollars per year, but did not seem to know much about hustling the business. When I asked him what we had better do to increase the revenue, he said, "Hire a solicitor and install more machinery." We finally secured a young man who had sold electricity in another town, and started him to work, and then began to make plans for increasing the capacity of the plant. We were charging ten cents per kw. hour and the young man had not been at work very long before he secured a contract for a wholesale house that would use about twenty-five arc-lamps. He also got contracts for several factories, and I began to think that there was a good prospect of his building up quite a business. However, I did not see any increase in the receipts, but the manager told me to wait until next winter and all these new customers would then be using the light. Of course we could not expect much in the summer, as they did not need it. Gas was selling at a dollar a thousand cubic feet, and a walk through the business district at night showed all the saloons, drug stores, restaurants and hotels using gas. Upon inquiry I found that the price of electric light to such consumers was about three times the cost of gas, and of course they could not afford to pay the difference. The solicitor's business soon began to drop off, and in a few months his orders were very few and far between. He merely said that he had secured every customer that he could and could not possibly get any more.

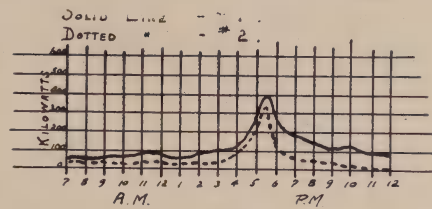
In other cities I have seen the electric light company light all the saloons, drug stores, etc., and wondered why we could not do it. So I began to look around and see if I could not find a man who could get the business. One day, in answer to one of my letters, Mr. Johnson, a man of about thirty-five years, called to see me, and in answer to my question as to what he could do, he replied that he did not know, but that if I would give him a guide and a right to ask a few questions, he could soon tell me. I did so, and the next day he returned and said, "I find that you have loaded your plant down with 'short burners.' About the only revenue you get is on the peak in the winter. You asked me how I could increase your net profits, and I will say that I can increase your net profits from twenty to thirty thousand dollars per year, and you need not purchase any more machinery." I replied that I did not see how that was

possible, as we could not raise our prices. He said that he would *cut* them to some customers and *raise* undesirable ones. "For example, you have a commercial light and power load of 600 kw. on the peak, or a revenue of fifty dollars per year per kw. demanded on the peak. Now, there are a great many concerns, such as saloons, drug stores, restaurants, hotels and other 'long burners' that you ask to pay at your present ten cent rate, $200 per year per kw. demanded, which is much too high. Imagine a drug store having forty 16 cp. lamps, paying you $400 per year. Their gas bills are not over $150 per year, but you will let a wholesale store that closes at 5:30 burn forty 16 cp. lamps and only pay you $50 per year, and they cost you nearly as much as the drug store. All of your fixed expenses are the same for both, but the drug store uses about 4,000 kw. hours and the wholesale store 500 kw. hours. As your coal bill is not over one-half cent per kw. hour, you can see the drug store would cost for coal $20, the wholesale house $2.50. So you are either making a very large profit on one or losing a lot on the other.

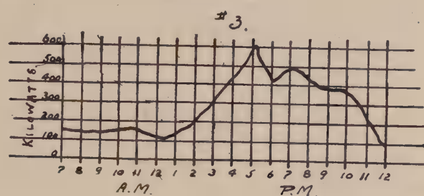
I could readily see that this argument was correct, and asked him how he would go about it to produce results. He replied that the town was not large enough for him to spend his entire time with us, but that he had in training several bright salesmen, any one of whom was capable of going into the town and working up the business under his supervision. Of course it would oftentimes be necessary for him to help the solicitor on some big contract, and that he would charge me $1,800 per year for the services of the solicitor, and for his own services he would ask 25% of the increased profits during the first two years; after that he would probably not be needed, as things would be running so nicely that the solicitor would be able to go it alone.

His desire to back up his ability with such a proposition made me feel safe in accepting it at once. He at once came on the ground to give us a start, and first got a friend of our company to agitate a rate ordinance, which was passed. It prohibited a charge in excess of fifty cents per month per 16 cp. lamp to customers using light not over ten hours per hay. The "long burners," of course, were pleased and boosted it along. The "short burners" never dreaming that it would affect them, said nothing. He then sent for the solicitor, who was instructed to charge a flat rate of $5.00 per month per kw. demanded and an extra charge of two cents per kw. to all light customers, except residences, who were to pay ten cents per kw. hour., $1.00 minimum. Lodge rooms, churches and hotels were to receive a special rate. The solicitor had no trouble in securing contracts with all the "long burners," and at the same time kept an eye open for unprofitable "short burners" and raised their price to the new rate. The wholesale house, when asked to pay ten dollars per month, plus two cents per kw. hour, threw up their hands in horror and said that they would not stand for any such "hold-up," so they put in gas.

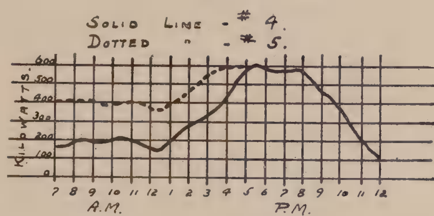
In October the load curve of the station looked like No. 1. The load curve before



NOS. 1 AND 2.



NO. 3.



NOS. 4 AND 5.

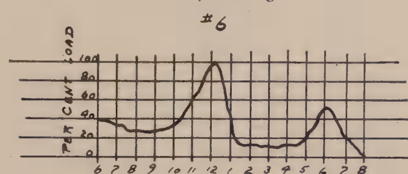


FIG. 6.

looked like No. 2. He said: "You will notice that the load drops off a little after six. If we don't do something we will have a curve like No. 3 in December. You will notice on No. 3 that it will begin to drop off at five P. M. I am going to start a strong campaign on residence lighting, churches and lodge rooms, which commence to burn at five o'clock and get heavier as the other load goes off. He engaged two bright young fellows and started them after residence contracts at the old price of ten cents per kw. hour. They would turn the names of all prospective customers over to a stenographer, who would

mail them a series of letters and advertising matter on electricity for home use. In that manner they would get from two to four contracts per day. All that time the solicitor was getting all the churches and lodge-rooms he could, at a six cent rate. It was not long before I could see a change in the load curve. It began to fill out after six, and by Christmas it looked like No. 4. He was not satisfied with that but said he wanted one to look like No. 5, and that he would get it with power business. I replied that factories did not stop work until 5:30, so their load would be on the peak. He said that large factories are on the peak, but small shops are not. He had studied their load and found that a load curve from a power circuit handling a great many large and small customers showed a load curve during December that began to drop off at four o'clock and reached zero at six, and at five o'clock it was only 50% of the total load, and that there were several large factories which he knew were on at five o'clock, consequently it must have been the small shops that began to quit at four o'clock and were practically all through at five.

He began to push power business at three cents to large and small customers alike. As there was no firm in town that handled motors, we sold them to our customers at cost. Such a low price on power secured a great many small power customers and a few large ones. He was gradually filling up the "valley" in the load curve, and our receipts in March were $5,000, which made me feel pretty good. About that time a big cold storage plant was being built, and Johnson went after the business, quoting a two cent rate. He told me that they would require 100 hp. about 600 hours per year, which, at two cents per kw. hour, would give us a revenue of $9,000, of which about 75% was clear profit. I had so much confidence in Johnson that I knew he was right, but I had to ask how the profit could be so much and how he could carry the increased load. "Nothing easier," he said. "They agree *not* to use power after 4 P. M. in November, December and January, so the only time they come near our full load is Saturday night in the summer time, and then our load is never more than 400 kw. Regarding the 75% profit, I am going to let you answer that. Do you have to put in any more machinery to carry the load?" I replied "No." "Do you require any more men to run your plant?" I said "No." "Then isn't coal the only added expense, and does it cost you over one-half cent per kw. hour?" I took off my hat to him. I could see his 75% profit.

When summer came, our receipts held up to about $4,000 per month. All the stores were paying their "flat rate." The power customers were paying more than they did in the winter, the refrigerating plant was paying us nearly a thousand dollars per month, and I began to see visions of a good paying property.

Johnson had an office system that was very thorough and yet very simple. He first bought one section (two drawers) of a vertical filing cabinet. The folders were numbered from "one" up. He had another drawer in which he kept his 3 x 5 index cards. When a new contract came in, a work order was issued in quadruplicate (two heavy copies and two tissues); one tissue was put in the customer's folder, and the two heavy copies and the other tissue went to the operating manager, who kept the tissue and passed the two heavy copies to the line foreman and the meter foreman. The operating manager's tissue was kept on his desk so that he could see what orders were in the hands of the men. When the men returned their copies marked "completed" he destroyed his tissue and passed the order back to Johnson, who passed them, with the contract, to the bookkeeper, who would enter customer's name and rate on the ledger, and then would pass them back to Johnson, who filed them in the customer's folder. He issued work orders for meter tests, complaints on service, etc., to the operating department in the same way, always filing his tissues at once, so, at any time, a glance in the folder would tell what the last move was. All prospective customers had a folder. After a visit, where anything of importance was said or done, he would dictate a "report" and file it. He also had a small deck tray, which he called the "tickler." One set of guides were for the twelve months, and one set for thirty-one days. I have seen him dictate a report on a prospective customer, saying that if Jones & Co. renewed their lease December 1st they would be glad to accept our proposition of April 15th." He would then drop a 3x5 tickler card in the tickler, for about December 1st, calling attention to report of April 15th on Jones & Co. He never tried to remember the slightest thing regarding any deal. If it were "up to the other party" he paid no attention to it and never gave it another thought. If it were "up to him" he would put in a tickler that would come up, say in ten days, asking if "Davis & Co. had answered June 12th," or "had P. C. Stewart sent him plans as per May 29th."

One day I asked him how a certain big power deal was progressing. He looked in the folder and found that the last thing done was a letter confirming a verbal quotation. It was signed by the solicitor, and we, to test the solicitor's system, looked in the tickler to see if he was taking care of it. We found a tickler dated eight days from the date on the letter, asking if the Iron Works had answered May 7th. He taught his solicitors never to use their memory, but to keep the system in first-class shape. He said that a good man could solicit at one time fifty large deals,

whose business would run from three thousand to twenty thousand dollars per year, and can tell any detail of any one of them in a very few minutes. After a call on a prospective customer, he should decide when he would call again, make his notes and then forget that such a deal is on.

There were about fifteen deals which he gave his personal attention in our town. I have seen him come into the office after a week's absence, look at a small memo book and say, "I must see Brown & Co. this trip." I would ask him "How about the others?" He knew no "others." He only knew those that turned up for that trip and under no circumstances would he go near any other deal.

He trained his men *never* to say anything while on a deal until they got all the information they could; then to go away and "form a plan of campaign," and when they got a plan that looked good to them, "go ahead and work it."

At the end of the second year the results showed that our revenue was $62,000 per year, and about the only increase in operating expenses was for coal. I was very glad to pay him according to our agreement, and insisted on retaining him at a salary of $1,200 per year in an advisory capacity only.

Our two largest hotels looked as dark and gloomy as they could, and the owners would not install any more lamps. The solicitor, by making a special rate for a few months, lighted one hotel until it made the other look like a dungeon. That made the owner of the "dungeon" sit up and take notice. As soon as the dungeon was well lighted and a contract was secured, the solicitor had no trouble in securing a contract with the other.

We made a special rate of three cents per kw. hour, with a minimum of five cents per month per two cp. lamp, on signs. the customers agreeing not to light them before 5:30. As they came on after our five o'clock peak, our cost was only one-half cent per kw. As the sign load would give us a revenue of nearly $60 per year per kw., we considered it the best kind of business. Johnson showed me that if we charged six cents for sign lighting, we would, as a rule, not get over $60 per kw. per year, as they would light them at 4:30 during the holidays, and be on our peak, there would be no profit to speak of, while at the three cent rate with the 5:30 start, it was nearly all profit.

The Gas company, seeing their "long burners" leaving them. and. in return, getting our outcasts (short burners). began a very aggressive campaign, and offered all sorts of cut rate propositions. Johnson told me to call upon their manager and tell him that if he did not quit that kind of warfare, we would give him a "dig" that would hurt. You can imagine what that manager said to me. After I reported the result of my talk with the gas manager to Johnson, he said that we would advertise complete electric cooking outfits for $80 on time payments, and would sell current for them at two cents per kw. hour. By advertising we had no trouble in assuring the public that it was cheaper, cooler, cleaner and more healthful than gas, and we put out fifty sets in two weeks. The gas manager came to me and asked me how much longer we were going to run that offer. I replied "Forever," and he went away declaring that we would go into bankruptcy if we continued at such a price. Johnson contended that we were making a good profit on it at two cents, as you see the cooking load runs like No. 6. It is an all day load until people begin to get their supper; the load at 5 P. M. is not worth considering, and it gradually gets heavier until after six. After we put in our new 500 kw. generator, we cannot get enough residences to fill our load curve out from five to six, so the cooking load will fill in there very nicely and only increase our expense a little for coal. The gas manager intimated that if we would put the price up to three cents, that he would quit cutting prices in the business district. But we were so strongly intrenched there that we thought we had better let the price remain at two cents, as it was a great "ad" for us.

You asked me how to organize and conduct a commercial department, and, after my experience, can safely say: hire the best commercial man in the country and let him do the rest. E. E.'s and M. E.'s are absolutely necessary in building and operating your plant, but don't expect them to be commercial men any more than you would expect your architect to manage your factory, office, bank or department store if he should build it. So far the electric lighting industry has paid the high salaries to the engineers, and have employed young, inexperienced solicitors at salaries from forty to one hundred dollars per month, to market the product from an investment of sometimes *millions*. For that reason "good salesmen" have never cared to go into the electric business, and consequently to-day, when there is millions of business to be sold, there are very few men capable of selling it. Let me show you the difference between a "good man" and a "cheap man." You wish to develop a certain very thriving factory district, where you have to make a long run to reach it, and you must secure a certain amount of business to warrant the extension. Your "good man" secures *75% of the business that he goes after*, your "cheap man" 30%. Your "good man." therefore, makes it possible to make the run. and thereby gives a big revenue from that district. while you get none from the "cheap man's" effort.

Review of the Technical Press

AMERICAN ITEMS

ELECTRICAL TRAIN LIGHTING SYSTEM. By W. H. Radcliffe.—*The Electrical Age,* October.

An illustrated article describing the different methods of train lighting, with particular reference to the means of generating and supplying current for electrical light. In summing up the subject the writer says:

"In conclusion, it may be said that multiple-unit axle-lighting systems are advantageous in that there is no attendance required en route, that power is obtained without connections between the cars, and that the illumination of each car is independent of the conditions of any other car of the train. The disadvantages are.—The apparatus is in part exposed and subject to mechanical injury; storage batteries must necessarily be used; erratic current generation develops commutator troubles; the units must be small and therefore comparatively inefficient; compensation for reversal of rotation complicates matters; the first cost is high, and the depreciation and maintenance are not low.

"Several of these disadvantages are overcome wholly or in part in different systems, and while there is a still opportunity for improvement along the lines mentioned, the practicability of multiple-unit axle-lighting system is proved by its adoption in one form or another, by over thirty prominent railway companies in the United States, and by more than 130 railway companies abroad."

ELECTRIC LIGHTING OF THE METROPOLITAN BRIDGE OVER THE SEINE. *Western Electrician,* September 29.

One of the principle features connected with the lighting of this bridge is the use of two circuits of electric lamps, one of which operates all night and the other a part of the night. A considerable portion of the article is taken up with the description of the switch employed in connection with the short time circuit. The lighting proper the following description is given:

"At first it was desired to use the system of incandescent gas lighting on the bridge, but as the passage of the cars causes a considerable amount of vibration, this being of very frequent occurrence owing to the large number of trains which are run on the line, the incandescent mantles would soon give out, especially as the lamps are mounted on the ends of long rods which hang down from the superstructure. The tests which were made of the incandescent gas system showed that it could hardly be used on the bridge, and again it was found undesirable to lay gas pipes across the bridge owing to the leakage of current which was to be feared between the current rail and the gas piping.

"Accordingly, the present system of incandescent electric lighting was decided upon, using 550 volts from the main line. There are 85 lamps in all, and these are placed in the hanging lanterns which will be noticed here. A cabin contains the main switchboard and the automatic device. The lamps are run in series of five. Some of the lamps, 35 in number, are cut off at 12:15 A. M., and the 50 permanent lamps run till daybreak.

"Two separate cables are run, one being the normal line, and the other the specially protected circuit for extra precaution. Thirty of the permanent or all-night lamps are placed on the protected circuit and 20 on the other, and the 35 variable or early lamps are connected on the normal circuit. This arrangement is used so as to provide for accident in one of the circuits and always have the bridge lighted. It is now desired that the lighting and extinguishing of lamps be done without having to look after them, and for this purpose an ingenious device is used."

The balance of the article is taken up with a description of the device.

THE LIGHTING OF CHURCHES. By J. R. Cravath and V. R. Lansingh.—*Electrical World,* October, 6.

The article takes up the general discussion of the subject, showing by photographic illustrations various systems in use in churches of different types of architecture, calling attention to the good points and criticising defects. Summarizing the various methods used, the writers come to the following conclusions:

With ordinary fixtures there are only two methods of church lighting which represent even an attempt to avoid the very objectionable feature of light shining in the eyes of the congregation. One method is to conceal the lamps behind architectural features, such as beams and pillars in a way that the light will shine down and forward, but cannot shine backwards so as to fall on the eyes. The method is good, but there are many churches or parts of churches where it cannot be done. Simply placing the lamps very high, while it is much better than having them low where they cannot be avoided by the eye, nevertheless is open to serious objection. As long as artificial light can fall steadily for some time on the eyeball, no matter from how high an angle, it will produce eye strain. The light must come from such an angle that the eyebrow shades the eyeball. This critical angle when a person is seated looking forward as in a church is about 25 degrees from a perpendicular drawn through the eyeball. To light a church well from a hygienic standpoint, then, we must have no rays of light shining backwards at an angle of more than 25 degrees from the perpendicular. The lighting must therefore be done by light shining down sidewise and forward toward the pulpit.

NEW BOOKS

Gas Lighting and Gas Fitting. By Wm. Paul Gerhard, C.E., Consulting Engineer for the Hydraulic and Sanitary Works, New York City. D. Van Nostrand Company, New York. 16 mo. Price, 50 cents.

This is a new (3) edition of the book which first appeared in 1887. The purpose of the book, as stated by the author, is "chiefly for the instruction of the gas consumer, the householder, but incidentally they will contain much information useful to those contemplating the building of a house, and to architects, builders, gas engineers and gas fitters, as well as sanitary inspectors, enabling them to acquire a better knowledge as to how best to introduce, distribute and utilize gas and gas-lights in buildings."

Illuminating engineers have often, and probably with much justice, complained of the lack of knowledge and attention on the part of architects in laying out systems of electric lighting. It is interesting to note that gas engineers have the same complaint to make, as is evidenced by the following (pp. 21-23):

"It is, unfortunately, true that, as a rule, not much attention is paid by architects and builders in the erection of new buildings to the means required for artificial lighting by gas. In the case of ordinary dwelling houses and stores the whole matter of gas distribution is left to the gas-fitters, many of whom employ either incompetent, inexperienced or careless mechanics, the architect concerning himself chiefly with the selection of ornamental gas fixtures which form a part of the interior house decoration. The details of gas-piping and gas fitting are seldom looked into, except in the case of large and important structures, such as churches, halls of audience and theaters.

"Wherever gas-light illumination is deficient, laymen are generally inclined to grumble about the gas-works, attributing the cause to the poor quality of the gas furnished by gas companies or to lack of pressure in the pipe system. There is, of course, occasionally good reason for the complaint that the gas supplied to the consumers falls far below the standard, but in the majority of cases the chief causes of bad illumination may be looked for in the gas apparatus of dwellings; in other words, in defective gas-fixtures, gas-burners, gas-globes and gas-piping.

"The general public is usually ignorant and indifferent about the subject. The gas companies, with few exceptions, do not keep the householder or gas consumer informed about the 'mysteries' of the subject, although it would be to their interest, without doubt, to enlighten the public, and to help them in every way possible to get the maximum amount of light and illumination from the consumption of a given quantity of gas."

The writer then proceeds to point out some of the loose practices that are in use, and the methods to be pursued in correcting them. The book is very clearly written, and treats in untechnical language of subjects with reference to gas fitting, and gas lighting, so far as the usual production of light is concerned, with which the householder and builder should be acquainted. The chapter on "How to read the index of the gas meter" is one with which every consumer should be familiar. The book should be in the hands of every user of gas, as well as the architect and gas-fitter.

FOREIGN ITEMS

EXPERIMENTS WITH AUXILIARY APPARATUS TO ASCERTAIN THE MEAN SPHERIC AND THE MEAN HEMISPHERIC LIGHT INTENSITY

(*Continued.*)

By Berthold Monash.

Electrotechnische Zeitschrift, July 26, 1906.

MEASUREMENTS.

Arc lamps seem to be wholly unsuitable for calibration tests of integrators, even though the conditions for axial symmetry by a perpendicular arrangement of the carbons and keeping the arc in the center are fully complied with. Incandescent lamps are more suitable, since their intensity does not change every few minutes, as the case of arc lamps, and since they have not so much outside influence on the value of the light intensity. Incandescent lamps in a spherical globe that has been frosted by sand blasting appear to be better for such tests than those with a clear glass, pear-shaped bulb used by Ulbricht and Bloch. There is a danger in the latter case in plotting the curve of distribution from which to find the mean spherical intensity, to measure also reflections of light, especially if the measurements are taken in a photometer room, the black walls of which act in certain positions of the lamp like a mirror coating on the clear glass globe. But such reflections do not occur in the Ulbricht globe.

For the tests of the globes and hemispheres used in the following experiments carbon filament incandescent lamps with

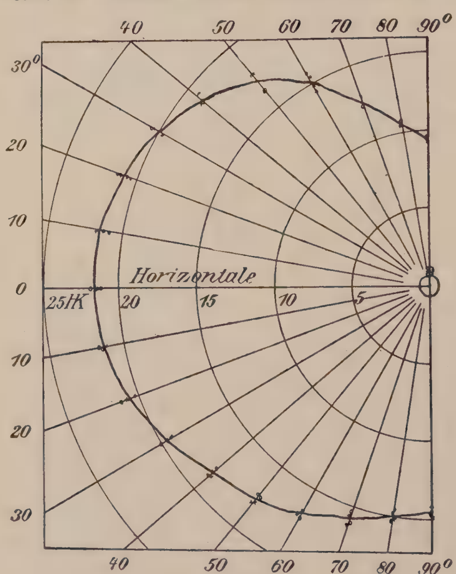


FIG. I.

frosted glass globes were used. By a previous photometric investigation the mean hemispherical and mean spherical intensities of these lamps were found by plotting the curve of distribution by dots, it was also found that the distribution of all the lamps was axially symmetric.

The curve of distribution in a vertical plane for lamp III is given in figure I. Curves of distribution of the other lamps show the same kind of curve.

For the measurements of intensities of the sources of light within the globes and hemispheres a Weber photometer fitted with a Lummer-Brodhun screen was chosen. There are two methods of making the measurements: either the illuminating of the opalescent glass window in the surface of the globe may be found by fastening the photometer to the window in such a way that the latter takes the place of the opalescent glass plate used in the well-known Weber's process for measuring illumination; or the photometer may be placed at a greater distance from the window of the globe, and its illumination found at a different distance from the photometer, assuming, as may be correctly done in the case of large globes with a small window, that the window is a plane having an equally distributed illumination.

By using the first method the illumination E of the window is:

$$E = \frac{C \,.\, 10^4}{r^2} \text{ lux}$$

in which r is the setting on the photometer scale in centimeters, and C the constant of the window. If Jo is the spherical intensity of the source of light in the globe to be investigated, then

$$E \,.\, K_B = Jo$$

in which Kb is the constant of the globe. Kb, therefore, is equal to $\frac{Jo}{E}$. If, in the second method, the distance from the window to the photometer is R centimeters then the intensity of the window is $Jf = \frac{R^2 \,.\, C^1}{r^2} H K$, in which C is the constant of the opalescent plate in the photometer screen. Then Jf . Kf = Jo and the constant of the globe Kf.

$$Kf = \frac{Jo}{Jf}$$

The value for the constant of the globe is different in the second method from what it is in the first, since, in measuring the intensity, the light passes through the window and the absorption of the glass must be considered in the constant of the globe.

It is better to measure the illumination on the inside of the window in the case of

sources of light that are relatively weak, while the measurement of the intensity of illumination of the window is best for strong light sources. In choosing the method it is the best to be guided by the power of the secondary standard used in the Weber photometer, and by the character of the opalescent glass plates available.

On account of the difference in the human eye two observers took the readings in each position from which the mean was derived.

GLOBE WITH A DIAMETER OF TWO METERS.

For ascertaining the constant of the globe incandescent lamp 1-4 were successively suspended in the center, and the illumination by indirect light of one of the observation windows (20 degrees above the horizontal plane) was measured. The constant C of the opalescent glass plate was 2.20.

The constant of the globe Kb was found to be 0.1165. For finding it by means of the incandescent lamps 1-4 a circular opening of 5cm. diameter was made in the cover closing the upper opening of the globe, which is white inside so as to give a diffuse reflection, for admitting the lead wires. The mounting was the same for all the lamps. It will be seen from the agreement of the 4 values for the constant Kb of the different lamps, that the different dimensions of the sources of light within the limits investigated have no influence on the value of the constant of the globe. To find the error that occurs when another observation opening is chosen incandescent lamp III was left in the center of the globe and the photometer was fastened to all the windows in turn along a meridian. The mean value for "r" has been taken from a larger number of readings bv two observers. The greatest deviations from the mean value of r in the adjustment at the photometer are given in per cent. of the mean value. It does not make any difference which of the observation windows is chosen, but it is best to place the observer in a convenient position.

In another test the error caused by the axial asymmetry of the Nernst lamp, model B, without globe, and with horizontal glowers, was ascertained. The Nernst lamp was placed in the center of the globe. Each of the windows was measured once when so illuminated that the plane of the meridian of observation. The greatest deviations coincided with the plane through the axis of the glowers was perpendicular to the plane of the meridian of observation. The greatest deviation from the calculated intensities of the spherical illumination from the constant of the globe Kb = 0.1165 and the observed illumination were +2 per cent. to 1 per cent. In this case the errors were positive sometimes in one, and sometimes in the other position of the glowers relative to the meridian. Hence these deviations from the real spherical intensity arise from errors in the reading and not from the axial assymmetry of the Nernst lamp.

A further test showed no deviation in the spherical intensity larger than 1 per cent. in the different eccentric positions of lamp III of 10 cm. distance from the lowest point of the walls of the globe to 10 cm. from the highest point of the walls. Hence, the eccentric arrangement of sources of light does not change the illumination of the observation window. If there is a change it is due to the different effects of the lamp mechanisms in the different eccentric positions. The cover on top that closes the globe has a diameter of 50 cm. If the cover is taken off, as is required, for instance, for the measurement of the spherical intensities of light that are not point sources, a part of the diffused light that would be kept within the globe of the lamp were in the center, escapes through the opening; this cone of light is limited by an angle at the centre of 28 degrees. The light that escapes through the opening represents a diminution of the illumination of the walls of the globe and causes the constant of the globe to increase. When, by an arrangement of the Nernst lamp without globe, and with horizontal glowers, in the center of the globe, the cover was removed, the constant was increased by 12 per cent. A weakening of illumination of the walls of the globe and consequently an increase of the constant of the globe also occurs by the absorption of light by foreign bodies, such as the bodies of arc lamps.

In order to investigate these conditions more closely one of the largest forms of arc lamps in use was examined in different positions in the globe. The arc lamp had carbons arranged perpendicularly one above the other, and was fitted with an oval globe. The total length of the rods was 0.68 m., height of globe 0.42 m., largest horizontal diameter of the globe 0.36 m. The globe was of alabaster glass. For the observations in all these experiments the window 5 degrees below the horizontal plane was chosen. A Nernst lamp with horizontal glowers, the spherical intensity of which was known, and which was present in the globe, together with the arc lamp that was not lighted though provided with carbons, served as the standard source of light. Besides a flaming arc lamp was investigated, the length of the body of which was 0.94 m., with a globe of 0.25 m. diameter; the outside reflector used in experiment 15 had a diameter of 0.38 m.

In all the measurements the same window with the same opalescent glass plate was used, and a standard light of constant intensity. The constants of the globe resulting from the different cases are therefore squares of the adjustments of the photometer.

In experiments 2 and 3 the large arc lamp is completely in the globe. This position could be chosen if the spherical intensity was to be ascertained. (Experiment 2 with globe, experiment 3 bare.) It may be seen that by arranging the whole arc lamp with globe in the integrator that the constant was increased by 32 per cent.; if the globe and casting is not used the increase of the constant is only 11 per cent. But since the illumination of the observation window is practically independent of the position of the source of light in the integrator, but dependent on the size of the foreign bodies, it is best not to suspend all of the arc lamp within the integrator. Bloch placed the point of light about 10 cm. below the highest point in the integrator for measurement of the spherical intensity of bare arc lamps, and obtained for different kinds of lamps the same constant. Experiment 4 shows, in fact, that for arc lamps without globes the increase of the constant is only 2.6 per cent. (if we place the point of light sufficiently high to have the parts of the mechanism that absorb most of the light outside of the globe) ; this percentage of error lies within the limits that must be allowed for photometer measurements of arc lamps in practice. The arc lamp used in experiment 4 is about the most unfavorable case because it has the largest frame. The lamp was provided with carbons of 325 mm. length and 20 mm. diameter. In the case of arc lamps with shorter frame and thinner carbons the increase of the constant is still smaller when so arranged that the point of light is 10 cm. below the cover. The conditions are about the same when no cover is used on the globe. If spherical measurements are to be taken in the globe without the cover, the opening should lie in the shadow of the point of light.

In the case of flaming arc lamps that have no lower rods, experiment shows that the increase in the constant of the globe is only 1.3 per cent., if the arc to be measured is 10 cm. below the plane of the opening. By placing the point of light 20 cm. below the opening the increase of the constant is 5.5 per cent.

Hence for measurements of the spherical intensity of bare arc lamps one constant is sufficient for the different kinds if the point of light is adjusted high enough (about 8-10 cm. below the highest point of the globe), because the resulting error is smaller than the errors that usually occur in photometering arc lamps. For instance, when the spherical intensity of an arc lamp is found by plotting from distribution. For measuring curves the spherical intensity of arc lamps with globes, however, it is necessary in every special case to ascertain the constant anew; first, since arc lamps that send much light in the upper hemisphere have to let down pretty deeply in the globe, so that there may be no loss of direct light when the plane of the opening is not covered, and much of the mechanism is brought in to the globe in this way; and second, because an arc lamp, the spherical intensity of which is to be ascertained in the condition in which they are to be used might influence the constant in an opposite sense than that of light absorbing foreign bodies. For instance, a case in which the globe of a flaming arc lamp was covered by a straignt metal reflector, the lower surface of which was enameled white, shows a decrease of the constant (globe without cover) of 6 per cent. The white part of the outside reflector acted here like a part of the cover and reflected the light back into the globe.

For measurements of hemispherical intensity which require that the point of light of bare arc lamps be placed in the plane of the circle of the opening, the largest error arising from the presence of the frame is so small that it is not necessary to ascertain the constant anew.

For measurements of the hemispherical intensity of arc lamps with globes it is necessary to find, by the grease-spot process given by Ulbricht, the position of the globe in the opening. Since in the case of lamps with globes the rods are behind the globe, it is not necessary to determine the constant anew.

The source of light must be exactly adjusted in the circle of the opening, especially for light sources of large dimensions. Bloch found an error of 12 per cent. in ascertaining the mean hemispherical intensity of an incandescent lamp when the position of the lamp in the circle of the opening was changed by 10 mm. Using lamp III in an opening of 50 cm. diameter of a two-meter globe an error of 1 per cent. was detected in the hemispherical intensity when the incandescent lamp was moved 1 mm.

If then, it is easier to find anew the constant of the globe in the presence of certain mechanical parts in the globe it appears that Ulbricht's process of finding the constant by means of a tested incandescent lamp is preferable to that of Bloch, who first finds the distribution of the arc lamp outside of the globe by means of dots. In the experiments made by the author to test the globe by means of arc lamps with vertically arranged carbons of the best quality the distribution of which had been found by plotting of the curve of intensities there were differences in the spherical intensity of 10-12 per cent. when a given lamp was photometered several times, in spite of the fact that the conditions for the experiments were always the same.

In using incandescent lamps for the testing of the globe in the presence of lamp mechanisms it is necessary to avoid direct rays of light on them. Ulbricht specified. therefore, that the test-lamp be placed in

the lower part of the globe; he had the lamp protected from above and also toward the observation window by a small shade. In the experiment a Nernst lamp with horizontal glowers without globe was arranged below the arc lamp. Such Nernst lamps send a very small flux of light into the upper hemisphere; in the measurements direct rays from the testing Nernst lamp reached the walls of the globe only, and not the mechanical parts. The latter absorbed only indirect light coming from the walls of the globe.

COVERED SEMI-GLOBE, DIAMETER 2 M.

The cover of the hemisphere had an opening of 2 cm. diameter for admitting the leading in wires. The cover had inside the same white diffuse reflecting coating as the walls of the hemisphere. Four incandescent lamps were used for testing of the hemisphere; their centers were placed 25 cm. below the cover. The photometer was at the window 15 degrees below the horizontal plane.

It is seen from this that the deviations from the mean value of the constant of the hemisphere found is not as much as 1 per cent. In order to try the effect of the covered hemisphere on axially asymmetric light sources, a Nernst lamp, Model B, with horizontal glowers, and without globe, was used. The glowers were 5 cm. below the cover and the center of the hemisphere. The distribution of light of the glowers is shown in Fig. 2. Curve 1 refers to that position of the glowers in which their axis lies in the plane of the observation

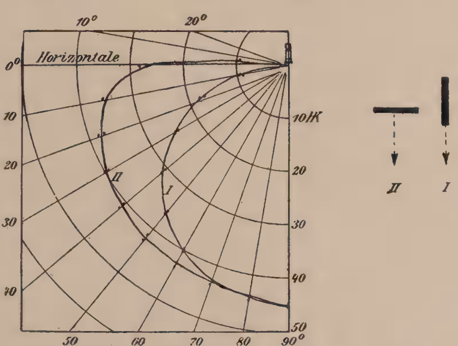


FIG. 2.

meridian of the photometer, and curve 2 when perpendicular. In plane 2 the Nernst lamp gives a maximum, in plane 1 a minimum intensity. A similar form of curve of distribution of horizontally arranged glowers (Nernst lamp) was found by Wedding ("Etz," 1903, p. 442) and Lux (*Zeitschrift für Beleuchtungswesen,* 1905, pp. 35, 49). To find the spherical intensity of the Nernst glowers in the hemisphere, the position of the photometer was chosen at the window 15 degrees below the horizontal plane. The glowers were placed in the observation meridian (position 1); they were then turned in position 2 for the same observation window, and were also measured in positions 1 and 2 for each of the other windows of the same globe. The largest observed deviations in the different positions was +1.77 —1.26 per cent. The deviations are of the same size as the deviations in the different positions of the glowers, and of the different positions of the photometer in the Ulbricht globe of 2-meter diameter, and are caused only by the readings on the photometer.

In order to investigate the influence of the eccentric positions of the source of light in the hemisphere the Nernst lamp was let down from 20 to 20 cm. farther in. In a position of the point of light at a depth of 71 cm. below the cover of the globe the largest error was +2 per cent. In the other positions the errors were sometimes positive and sometimes negative.

This investigation shows that in the covered hemisphere also the illumination of the observation window by indirect light is practically independent of the position of the source of light, the observation window used, and the form of curve of distribution of the light source. Hence, the covered hemisphere is equivalent in its effect to the whole globe of the same diameter. It appears also that integrators may have forms geometrically different from globes and hemispheres if the total flux of light from the light source can be completely encompassed in a hollow body that gives a complete diffuse reflection within.

For practical application the covered hemisphere, especially with large diameter, offers certain advantages. Its cost of production is less than half of the whole globe of 2 m. diameter, as the upper half of such a globe has to have certain auxiliary arrangements. The upper half of the globe has a diameter of 2 meters and weighs about 100 kg. It can therefore not be lifted off by hand, but has to be supported on runners in order to be moved aside for the purpose of cleaning. The 2 m. globe is so high that the operator has to climb on top of it in order to adjust arc lamps above its center. In photometer rooms that are not very high it is difficult to insert long arc lamps, especially if the point of light is to be placed in the circle of the opening, or a few centimeters below it.

But, if the hemisphere is used, one man standing on the floor can manage it. The cover may have any number of subdivisions, can be put on by hand, and arc lamps are easily adjusted.

For measuring the hemispherical intensity of incandescent lamp No. 3 an area of 30 cm. diameter was left open in the cover of the hemisphere. In this case, too,

there was a large error of about 1 per cent. if the incandescent lamp, after correct adjustment of its center of luminosity, was moved by 1 mm. out of the position given in Ulbricht's method. Hence it is necessary for measurements of lamps with globes to cut larger areas out of the cover. For that purpose it is best to have the cover composed of a number of concentric rings, of which the one best suited may be taken out.

NOTES ON GLOW-LAMP STANDARDS AND GLOW-LAMP PHOTOMETRY

By J. S. Dow, B.Sc.

The Electrician (London), September 14, 1906.

The secondary standards of light now in general use are practically restricted to standard glow lamps and flame-standards, usually of the Methven screened type. It is generally considered preferable to use a flame standard, when testing gas lamps of any kind, and a glow-lamp standard when testing glow lamps. The variations in candle-power of flame standards and flames in general, due to the influence of water vapor and barometric pressure, are now known to be considerable, and it is probable that under the usual conditions of testing the effect of vitiation of the atmosphere of the photometry room is quite as important. If a glow-lamp standard, which is presumably independent of atmospheric conditions, is used for testing gas lamps, all these causes of uncertainty would affect the gas lamps tested and not the glow lamp, while, if a gas standard is used, the influence of water vapor, etc., would affect both the standard and the lamp tested simultaneously, and will therefore be less noticeable. At the same time we have no right to assume that two different types of lamps such as a Methven standard and an incandescent mantle, would be affected in the same degree. If accurate results were wanted, probably the best plan in such a case would be to use an incandescent mantle as a temporary standard, so that any atmospheric change affected both standard and lamp tested in exactly the same way.

Further, when a glow-lamp standard is used for testing gas lamps, the regulation of the P.D. to the necessary degree of accuracy is usually a difficulty.

In the same way it is not advisable to use a secondary gas standard when testing glow lamps, for in this case all atmospheric changes will affect the standard and not the glow lamps, while if the standard glow lamp is used this difficulty is, of course, absent. Moreover, if the standard glow lamp and the glow lamp to be tested are run in parallel off the same P.D. any change in the pressure affects both lamps together, and hence it is quite sufficient if the P.D. is regulated to 1 or even 2 per cent.

It is to be noted, however, that as a rule two glow lamps, even of a similar class, are not affected by a change of P.D. in exactly the same way, and hence the ratio of the candle-power of one to the other is distinctly affected by a change in the P.D. of 5 per cent. or so.

For instance, Table I below shows the result of comparing two 100 volt nominally 50 cp. glow lamps when run in parallel off several different P.D.'s.

Table I.—Comparison of the 100-volt 50 cp. Glow Lamps.

P.D. (volts).	Ratio of candle power: Lamp No. 1 / Lamp No. 2
87.4	0.767
91.2	0.778
95.0	0.785

A change of 1 per cent. in the P.D. would thus cause an error of something like 0.25 per cent. in the determination of the candle-power.

When we are comparing a Nernst, tantalum, or osmium lamp with a standard glow lamp, run in parallel with it off the same P.D., the exact regulation of this P.D. becomes much more important. For, while the candle-power of the glow-lamp varies with about the seventh power of the P.D., the candle-power of tantalum and osmium lamps appear to vary with about the fourth and fifth power respectively, and the candle-power of the Nernst lamp, on account of the iron wire resistance in series with it, is practically independent of small variations in the P.D.

Table II shows the result of comparing a tantalum lamp with a standard glow lamp, run in parallel with it off the same P.D., for several values of the P.D.

Table II.—Tantalum Lamp compared with 100 volt Glow Lamp.

P.4. (volts).	Ratio of candle-power: Tantalum lamp / Glow lamp
91.2	0.576
95.0	0.530
97.0	0.505

Here a difference of 1 per cent. in the P.D. across the two lamps would make a difference of as much as 2.5 per cent. in the candle-power of the tantalum lamp.

It will also nearly always be found that if two glow lamps—even two lamps having precisely the same type of filament—be compared at distances varying from 1 meter up to 3 meters, the results tend to gradually change as the distance increases. Below are the results of comparing an ordinary 100 volt 8 cp. Robertson lamp against a similar 100 volt 16 cp. lamp, both having filaments of the usual type for low-voltage lamps, as distances varying from

1 to 2½ meters. In the figure is shown the appearance of the filament looking down the photometrical bench towards the lamps. The lamps were therefore placed in the position in which they are usually tested—*i. e.*, the position in which the candle-power is a maximum.

and calibrations of this instrument, with a potentiometer, over nearly six months agreed to within 1-16 per cent. The reflecting voltmeter now in use at the National Physical Laboratory enables measurements to be made which are well within the limits of photometrical observation.

TABLE III.

Type of lamps compared.	Distance between lamps.	Ratio of C.P.: 16 c.p. lamp. / 8 c.p. lamp.
Robertson 100 volt 8 c.p. and 16 c.p. lamps.	250 cm.	2.38
	220 "	2.37
	200 "	2.35
	170 "	2.33
	140 "	2.34
	120 "	2.33
	100 "	2.32

In spite of every care in the centering of the lamps and the photometer, the writer has almost invariably found differences of this kind, and when the lamps are of quite *different* types, the differences may be very much greater. They are presumably due to the fact that the true center of illumination rarely lies on the central axis of the lamp bulb from which we measure. For accurate work, therefore, it is desirable that a certain distance between the lamps compared should be generally agreed upon. Standard lamps should have filaments of the simple horseshoe type, lying entirely in one plane. In this case, when the plane of the filament is set perpendicular to the bench, a slight turning of the lamp about a vertical axis only affects the candle-power very slightly, while the center of illumination must lie within the plane of the filament.

When a glow-lamp standard is used to study the variations of a flame standard the P.D. must, of course, be very exactly known. Dr. Fleming, indeed, in 1902 (*Proc.* Inst. of Elec. Eng., 1902, Vol. XXXII., p. 144) put on record his opinion that no voltmeter in existence was sufficiently accurate for this purpose, but there seems no reason why a reflecting voltmeter, constantly compared against a potentiometer, should not answer for all but very accurate investigations indeed. The writer, when working at the Central Technical College, used a reflecting electrostatic voltmeter with a very open scale in the neighborhood of 100 volts with satisfactory results. A change of 1 per cent. in the P.D. at this point corresponded to a division nearly ½ in. in length on the scale,

As the P.D. across the standard lamp must be known so exactly, contact resistances in the lampholder may quite possibly give trouble, especially if the resistance of the lamp is low. For this reason screw-holders are preferable to those of the bayonet type. At the Reichsandstalt the results of contact troubles are entirely avoided by measuring the current through the lamp instead of the P.D. across it. This method has also the incidental advantage that the candle-power of the lamp is proportional to a lower power of the current than the P.D., and hence the former need not be known so exactly. It has also advantages which will be referred to shortly.

All glow lamps appear to be more or less subject to the "hysteresis effect." If the P.D. across a lamp be maintained for a short time at a higher value than that at which the lamp is normally run, both the current and the candle-power are usually perceptibly higher than before, when the P.D. is brought down again to the usual value. Table IV shows the effect in the case of two new ordinary 100 volt 16 cp. lamps, taken at random, of the Robertson and Sunbeam makes respectively. The lamps were tested at 95 volts. They were run at 110 volts for three minutes and again tested at 95 volts, then at 120 volts for three minutes and again tested at 95 volts, and finally at 130 volts for three minutes and then again tested at 95 volts.

The effect seems perceptible even when the lamps had only been run at 110 volts, and the writer has usually found that overrunning a lamp by only 10 per cent. for 10 minutes or so produces a distinct effect. As a rule the increase in candle-power at a

TABLE IV.

Type of lamp.	Before overrunning. At 95 volts.		After overrunning. At 110 volts, for 3 min. at 95 volts.		At 120 volts, for 3 min. at 95 volts.		At 130 volts, for 3 min. at 95 volts.	
	Current.	C.P.	Current.	C.P.	Current.	C.P.	Current.	C.P.
Sunbeam......	0.535	9.48	0.535	9.53	0.538	9.68	0.542	10.00
Robertson.....	0.543	9.70	0.544	9.72	0.545	9.70	0.550	9.97

given P.D. seems to be caused mainly by a temporary decrease in the resistance of the lamp, and consequent greater power consumption. But in some cases there seemed to be a small change in candle-power without any noticeable change in current, showing that the efficiency of the lamp had been increased, for the time being, by overrunning. But if the current through a standard lamp, instead of the P.D. across its terminals, is always maintained at a constant value, the increase in candle-power caused by slightly overrunning the lamp will be, to a great extent, avoided. Nevertheless it is desirable that the P.D. across a standard lamp should never be carried above that at which the lamp is normally used.

As a rule, when left alone, the lamp tends to gradually return to its former

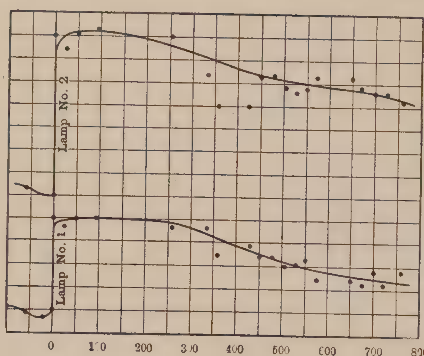


FIG. 3.

state, the time of recovery depending on the severity of the strain to which it is subjected. The behavior of two 100 volt 50 cp. large bulb lamps, which were used as secondary standards, is shown in the figure.

These two lamps were always used at a P.D. of 95 volts, but one day they were accidentally run at—probably—nearly twice this value for a few seconds. The filaments, however, did not give way, and the lamps were immediately retested, when it was found that their candle-powers had increased by about 4½ and 7 per cent. respectively. A record was kept of the candle-powers of these for about a month afterwards. They were run at 95 volts, and were always compared, in exactly the same position, with the same standard. The gradual fall of candle-power during the month showed that the lamps were gradually returning to their original state, but at the end of the month they were still about 2.2 and 4.2 per cent. respectively above their former values. It should be explained that the small length of time during which the lamps were in use, and the low efficiency at which they were run, showed that this change could not be accounted for by the natural ageing of the lamps. Previously to the accident, the lamps had been used in the same way for about two months without any distinct fall in candle-power being noticed.

This recovery of lamps is of interest in that it may affect the question of the ageing of the standard lamps before use. The candle-power of most glow-lamps changes very rapidly for a short time at the commencement of their lives, and it is customary to age standard lamps by running them for 50 to 100 hours or so, at their prescribed voltage, or slightly above it, in order that this change may be complete before they are put into use. It seems possible, however, that in so doing a strain may be put upon the filament, resulting in a subsequent slow recovery and gradual fall of candle-power. The lamps, therefore, should be allowed to rest for some time after the "ageing," in order to reach a steady state.

There is one other possible source of uncertainty connected with standard glow lamps to which reference should be made. In the discussion of Dr. Fleming's Paper, in 1902, Mr. J. T. Morris (*Proc.* of Inst. of Elec. Eng. *ref. cit.*) drew attention to the variation in candle-power of a glow lamp owing to changes in the temperature of the photometer room. He found that a change in temperature of 9°C. produced a change of 1 per cent. in the candle-power of the glow lamp. At the Central Technical College the temperature of the photometer room varied about 12°C. from the beginning of February till August in the present year, and according to the above figures this would produce quite sufficient effect to be worth taking account of in a standard lamp.

It seems likely that the study of some of the newer metallic filament lamps may lead to a greatly improved incandescent standard. The tantalum lamp, for instance, has the advantage that the candle-power is only proportional to about the fourth power of the P.D. across the lamp, while it seems likely that at low efficiencies its life would be distinctly better than that of glow lamps. On the other hand, the difficulty of producing such lamps for high voltages would be of little importance in the case of a laboratory standard.

Dr. Kuzel's metallic filament lamps (*Electrician*, February 9 and March 9, 1906), so far as may be judged from the information which has at present been published about them, might also prove valuable. The fall of candle-power with use at moderate efficiencies is said to be very much less than with carbon filament lamps, and, from the fact that the lamps are said to be very little affected by being overrun even 300 per cent., one would suppose that "hysteresis effects" would be inconsiderable, and that such a standard would not easily be damaged by incautious regulation of the P.D.

Miscellaneous News

COLUMBUS, O.—The city council will authorize the employment of a recognized expert in electrical light plant matters to come to Columbus and investigate the local light plant and the city generally to see if the city can profitably engage in commercial lighting. Pending that information, the council will not issue any bonds for installing additional machinery asked for by the service board. The Columbus municipal lighting plant has already eaten up a fortune and has proved a failure. The managers have made another demand for money, this time for $140,000, but the city council has not had the temerity to ask the people to sanction another bond issue. The investment in the lighting plant within a few years has grown from $63,000 to nearly half a million, and more money is needed. A short time ago, when $100,000 was put into the plant, it was promised that the concern would be the finest in the country. Director of Public Service Lied said that if more money is not forthcoming at once the plant will be thrown out of business and the $500,000 lost. He says the present plant is wholly inadequate. The city is paying private electric light companies $200 a night to light the streets that the municipal plant cannot take care of.

FORT SCOTT, KAN.—For some time the people of the city have been anxious to know just where "they are at" regarding the proposed electric lighting plant in connection with the operation of the waterworks plant. The consulting engineers from Kansas City, who were employed to present an estimate of the cost of the same, have been working on the matter for several weeks and will be ready to report at the next regular meeting of the council. The report will embody two kinds of lights—straight arcs and incandescent arcs. The latter will simply be for the residence district if adopted, while in any event straight arcs will be used in the business district. But there will be more of them.

FORT SMITH, KAN.—Mrs. Fannie Cohn has applied to the council for a franchise to construct and operate an electric light plant in the city of Fort Smith, and an ordinance has been introduced in council to that effect. The ordinance specifies that the work upon the construction of the plant and system shall begin within six months from the date of passage of the ordinance and be completed before January 1, 1908.

GRAVETTE, ARK.—Capitalists of Carthage, Mo., are making arrangements to establish an electric lighting plant at Gravette. Many of the business men of Gravette have signed an agreement to take lights from the company. A proposition is before the county to grant a franchise to the company to operate the lighting plant.

JOPLIN, MO.—For some time there has been a feeling of dissatisfaction among the members of the city council because of a lack of dividends from the city electric light plant. The cause of this is claimed to be the lowering of rates by other companies in this city. It is said that the other companies have so cut rates in competition with the city plant that the prices are entirely too low for the city to make anything out of the investment.

LONG BEACH, CAL.—The city trustees are investigating the proposition to establish a municipal lighting plant. Data has been asked for from different sources and it is not thought improbable that the matter will be acted upon in the near future.

LORAIN, O.—Dissatisfied with the lighting service of the local illuminating company, a private corporation, the Board of Public Service is contemplating the establishment of a municipal lighting plant. The local concern furnishes both gas and electricity, and the board members say that the lights are often so dim that they are of little use. The service board has discussed the municipal ownership project at a meeting, and may proceed with more positive action.

LOS ANGELES, CAL.—The discovery has been made by the board of public works that a saving of $30,000 a year can be effected in the lighting of Broadway, Spring, Main and Hill streets. When the ornamental lights were first installed on Broadway a certain amount of electric energy was contracted for. Later the amount was reduced tohalf without affecting the lights. On Spring street the lamps are now burning the original amount of energy twice the amount being burned on Broadway, and there is no perceptible difference. After January 1st the Spring street energy is to be reduced.

MT. VERNON, N. Y.—Mayor Edward F. Brush filed with the commission of gas and electricity a complaint against the Westchester Lighting Co., alleging that under the terms of a contract with the city, the Westchester company agrees to supply electric arc lights of 1,200 candle-power, Welsbach lights of 60 candle-power and open-flame gas lights of 22 candle-power; that the city has had tests made of such lights under the most favorable conditions and that the highest candle-power of any of the arc lights did not exceed 180 and many of them 75; that the candle-power of the Welsbach lights did not exceed 20 and that the candle-power of the open-flame lamps fell as low as 4 and 5. The

complaint sets forth that the residents of the city are compelled to pay for electric current for lighting purposes at the rate of 20 cents per kilowatt-hour, while directly across the street, dividing the city of Mt. Vernon from the Borough of the Bronx, in a much more sparsely settled community, the company supplies such current for 10 cents per kilowatt-hour. The mayor believes this charge to be "exorbitant, excessive, unjust and oppressive." The illuminating power, purity, pressure and price of gas is also complained of and the commission is asked to hold an investigation.

NEW YORK CITY.—John C. Sheehan and his associates are working on a project for establishing a system of power houses for supplying electric current for light and power purposes in competition with the New York Edison Co. To a reporter of a city paper, Mr. Sheehan said: "We are going at this thing in an entirely new way. We do not believe that the whole lighting and power plant of a city as great as this, should be in the hands of one corporation, or that it should rest upon the security of one power house. If anything should happen to that power house, practically the whole city would be thrown in darkness. We are going to have the power subdivided to such an extent that any accident to one of our power houses will not jeopardize the city's lighting as a whole. We expect to sound the death knell of gas as an illuminant."

NEW YORK (Borough of Brooklyn).—The Queens Borough Gas and Electric Company, which supplies light to residents of Belle Harbor, Rockaway Park, Rockaway Beach, Arverne, Edgemere, Far Rockaway, Lawrence, Cedarhurst and Woodmere, and as far east as Lynbrook, has announced that on November 15th next it will reduce the rates for electricity 25 per cent. At present consumers are paying 20 cents per 1,000 watts for electricity, but when the new rate goes into effect the charge will be 15 cents per 1,000.

ORANGE, N. J.—The Orange Common Council has practically decided to receive bids for a municipal lighting plant on October 25. A form of proposal was considered calling for bids for three engines and electric generators, switchboard, poles, wires and equipment for 350 arc lights.

OSWEGO, N. Y.—The State commission of gas and electricity has granted the application of the Citizens' Lighting Co. of Oswego for authority to transact business and to issue $75,000 in stock. The conditions are that work be commenced before November 30th and only $50,000 of the capital be used in construction.

PASADENA, CAL.—Pasadena is meeting with all sorts of trouble in its efforts to establish a municipal lighting plant. Bonds for $125,000 were voted some months ago, but their issuance was enjoined by the Edison Company. Then the city council decided to build a plant from the current revenue of this year, figuring that they could squeeze out $52,000 for that purpose. And now they are threatened with an injunction suit, if they attempt to do this.

SCHENECTADY, N. Y.—The committee of the Business Men's Association appointed to make an investigation into the matter of cheaper electric lights, has carefully investigated the prices charged for electricity in various cities and has secured a report from Frank C. Perkins, eminent engineer of Buffalo, who after an investigation of the conditions says that electricity for lighting purposes in this city should not cost over 7½ cents per kilowatt-hour and the cost for arc lights for street lighting should not cost over $50 per year per lamp. These facts were presented by the committee to Hinsdill Parsons, president of the Schenectady Illuminating Company, who said that for some time the company had been considering a revision of the schedule of prices of electricity for both private and street lighting and spoke favorably of a substantial reduction in the near future. The illuminating company is now preparing a schedule of reduced rates.

SAN FRANCISCO, CAL.—The San Francisco Gas and Electric Company has issued notices to its consumers of a modification of the rates for both gas and electricity, the new schedule taking effect the 1st of the current month. The company makes a reduction below the established municipal rate in both gas and electricity in certain quantities. On gas, with a monthly consumption of 10,000 cubic feet or less, the rate is 85 cents per 1,000; over 10,000 and less than 20,000, 80 cents; over 20,000 and less than 30,000, 75 cents; over 30,000 and less than 40,000, 70 cents; over 40,000 and less than 75,000, 65 cents; over 75,000, 60 cents. On electric lights the municipal fixed rate is 9 cents to 5.4 cents, according to consumption, per 16-candle-power lam, equivalent per month, for installed load; then, according to gross quantity used, as follows: Upon the monthly consumption of: For 375 to 649 kilowatt-hours, 5¼ cents per kilowatt-hour; from 650 to 924, 5 cents; from 925 to 1,199, 4¾ cents; from 1,200 to 1,474, 4½ cents; from 1,475 to 1,479, 4¼ cents; from 1,750 or over, 4 cents.

WOODBURY, PA.—On November 6th the voters of this city will vote on the question whether or not the city shall "construct, maintain and operate a municipal light, heat and power plant." The Public Service Corporation is now furnishing the city with light, and owns an unused plant here. The question of buying this will come up later, if the vote is favorable to the new move.

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Illuminating Engineer

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Public Lighting in Boston

By L. D. Gibbs.

TREMONT STREET OPPOSITE COMMON, LOOKING TOWARD BOYLSTON.

Boston is a thoroughly well lighted city. This is its peculiarity—electrically. Unlike New York it has no single and lonely band of light running diagonally across the middle of a scant night. But on every street an unusually complete, full proportioned illumination prevails. Such a condition accords with the comfortable contentment of the average Bostonian.

Striking features in electric illumination, however, abound. Tremont and Boylston streets, skirting the Common which gives a magnificent frontage for their fine stores and theaters and the aristocratic Touraine

TREMONT ROW, ONE SIDE OF SCOLLAY SQUARE.

hotel at the corner, form a striking scene at night, while the spectator need but turn half around to get an inspiring view of the classic State House dome shedding a golden glow over Beacon Hill.

Just a block away runs the winding thread of Washington street, known the world over as Boston's shopping street. Our ancestors were altogether too "'skimpy" about the width of their cow paths or this one might have been the original "White Way." Tremont row, Hanover street, parts of Summer street, and the broad avenues of the Back Bay section are surprising in the ingenious and abundant devices adapted to advertising purposes.

The shining State House dome is probably the most striking piece of electric illumination on the New England coast. For some months it has not been illuminated, while a fresh layer of gold leaf is being spread over its surface, but when the many lights are turned on the solid brilliancy can be seen from miles away. From inland it appears like the full moon rising behind trees and hedges, retreating and approaching in hide-and-seek fashion. From the distant harbor the view is wonderfully impressive. In midsummer, when the myriad lights of the shore resorts and the fantastic outlines of electric threads strung over the buildings in Wonderland—Boston's Coney Island—give one an impression that life on the Massachusetts shore is a continual holiday, the solid light reflected from the central dome is the feature of the scene compelling attention.

The illustration on the cover is reproduced from a photograph taken at 10 o'clock on a recent winter night. Pleasure seekers were not thronging the Common on that frosty night but the scene was one never to be forgotten.

HANOVER STREET, A THOROUGHFARE TO THE NORTH END.

The views reproduced with this sketch show the typical and most familiar sections of Boston where electric lighting has been skilfully applied for combined decorative and advertising purposes. The word decorative is used advisedly, for you must know that the dominant sentiment in Boston is opposed to the big glaring sign and every attempt to put one up in any place sufficiently public to make the advertising of any value is fought and thwarted if there is any power on earth or in the Massachusetts statute books to do it. So, the problem in Boston is to get a sign or other device that will attract attention and at the same time be inconspicuous or at least not too jarring. Try it. For possibilities "How old is Ann" isn't in it.

The photographic work for these illustrations was done by one of the corps of photographers of the Edison Electric Illuminating Company of Boston. The average exposure for each plate was 12 minutes, though a much longer time was taken at each setting up of the camera, owing to the necessity for covering the lens when automobiles and street cars were passing.

The view on Tremont street is looking in a southerly direction down the street toward the Touraine hotel. The brilliant illumination of Keith's theater produced with arc lights in opal globes, is the prominent feature. On either side are excellent examples of effective window lighting and the small but attractive signs in the middle of the view call attention to several prominent stores. A little to the right of the center are the signs on the Tremont theater advertising "Madame Butterfly" as the attraction, while the sign of the Majestic theater is seen in the distance. The "Budweiser" sign topping a big building at the corner of Tremont and Boyls-

WASHINGTON STREET, LOOKING SOUTH FROM MILK STREET.

ton streets, shows up well in the picture which gives some idea of its prominence as an advertising feature. The rental value of this location is understood to be in the neighborhood of $500 a month and its only competitor in expense and prominence is a "Peter's Chocolate" sign which has been planted, directly opposite, across the Common, high up beside the Park church spire on the edge of Beacon hill.

From the point at which this picture was taken Tremont street runs northwest alongside the Common past St. Paul's and Park churches and King's Chapel, between Tremont Temple and the big Tremont Building down to Scollay square. At this point the street becomes Tremont row and again gives up one side to the space allotted to the square, which, by the way is the usual triangle. Here one finds the most concentrated and brilliant illumination in Boston. It is the playground of the working people. It is also the "Four Corners" for the thousands of people from the swollen suburbs beyond the city coming and going through the North station, the East Boston tunnel and the ferries.

All is hurly-burly, helter-skelter. The square is filled with street cars, cabs, wagons and people who must be caught and held if only for a few minutes. As a result bands are playing, horns tooting, fiddles wailing and freaks dancing while the electric lights are compressed into every conceivable pattern and variety of color to attract. The accompanying view shows the features in an amusement way. Austin & Stone's museum containing "all the wonders of the earth," the 1-c. Automatic Vaudeville and the Theater Comique. Before these places crowds stand in line often for an hour at a time waiting a chance to buy tickets of admission. In the meantime the shopkeepers are busy.

WASHINGTON STREET, LOOKING SOUTH FROM HAYWARD PLACE TO BEACH STREET.

The time is short. The crowd will be gone by 11 o'clock; for all Boston goes to sleep, or at least gets under cover at that hour. The many small but prosperous shops in the locality go in for electricity and all they can get of it. If it draws crowds to the shows why wouldn't it draw business? And it does.

The view here shown was secured under difficult conditions. At best only a few seconds of exposure could be given before the cap went on to shut out the trolley cars. Then the glistening surface of a hack or the gloomy frame of a truck wagon would spread over the lens. Then the crowd began to gather to await the "explosion" which a knowing one who had probably had his picture taken by flash-light after a boxing bout asserted would "come in a minute." Finally the "cop" appeared but he was good and waited until he saw a fresh plate go into the machine. He couldn't rest longer. "Dhon't bhe bhlocking up the sthreet; it's made fur teems. Move 'long."

Another view shows Hanover street, the prominent retail business thoroughfare of the North End, running from Scollay square northeast through Haymarket square to the East Boston ferry. This picture was taken at the Scollay square end of the street on a Saturday night. As in the other views the throngs of people filling the sidewalks cut off much of the brilliancy of the show windows, but a good idea is given of the variety and extent of the sign advertising. The prominent signs are on clothing stores with the exception of Wilson's, jeweller and optician, and Marston's restaurant. In the distance the big building occupied by the Jaynes Drug Company is outlined in electric lights while the signs still further away call

SUMMER STREET, LOOKING SOUTH TOWARD SOUTH TERMINAL STATION FROM CHURCH GREEN.

attention to "Cobb's Groceries" and "E. E. Gray & Co." groceries. The light lines down the middle of the street were made by the headlights of an intruding automobile.

The two pictures taken on Washington street include the most familiar sections from Milk street south to Beach street, the first including the Shuman Corner, Keith's and the Boston theater, which show in the distant center of the plates. The sign lighting here is effective though somewhat scattered. The Boston Tavern sign though not brilliant never fails to attract attention because of the shaded colors in the glass. In the vicinity of the Shuman Corner are a number of flaming arc lights which make the street as bright as day but do not improve the detail of the picture. An interesting feature of the view are the lanterns placed along the torn-up street. They shine in the picture, of course, by reflected light.

The second section of Washington street pictured herewith shows good results in sign lighting and the flaming arcs maintain the general lighting already seen in the upper portion of the street. The rows of lights on the Globe theater at Beach street are shown in the distance. The Ginter Grocery Co., has an unusually brilliant lighting scheme.

Another idea of illumination for advertising purposes is shown in the view down Summer street from Church Green towards the South terminal station. This street is jammed with "commuters" from 4:30 in the afternoon until about 7 o'clock in the evening. A little later the march into town is taken up by the "theater people." For these and the crowds that go by in the street cars the merchants keep up a full illumination.

Plain Talks on Illuminating Engineering

By E. L. Elliott.

THE MEASUREMENT OF MEAN SPHERICAL CANDLE-POWER

In expressing measurements of illumination it must be carefully borne in mind that multiples of the unit are formed by multiplying the standard light, and not the distance. For this reason, it is better to use the words in the order already given, with the term expressing the distance in the singular, thus: one foot-candle, two foot-candles, etc. Efforts have been made to substitute this compound term with a single word, "lux," but this has not come into general use, and is not understood except by professional scientists, and not even generally by them.

The term "candle-power" is often used in such a manner as to give the impression, at least to the uninitiated, that it signifies a quantity of light. Thus, the rating of an arc lamp as "2,000-candle-power" naturally suggests that such a lamp gives 2,000 times as much light as a candle! and such is undoubtedly the belief of the large majority of laymen, and not improbably also, of a considerable number of engineers and electricians. Or again the average user understands that, with "20-candle-power gas," the flame of an ordinary gas jet must give as great a quantity of light as 20 candles; but the term so used has no such meaning. Keep in mind that the term "candle-power" when used without any additional qualifying word or term, always refers merely to the *intensity of light rays* in some given direction, the horizontal direction being understood unless otherwise specified.

We have just seen that to express brightness, or intensity of illumination, the word "foot," or some other term expressing distance, is coupled with the word "candles." To express a quantity of light the word "spherical" is used in connection with the word "candle" or "candle-power"; but in this case the meaning of the word "candle" depends upon theoretical or imaginary conditions. We may describe this theoretical "spherical candle" as a light-source giving out rays of a uniform intensity of one candle-power in every direction. As we stated early in this discussion, an actual light-source never gives out its light equally in all directions, and a candle flame comes very far from giving out its rays uniformly; the "spherical candle" is therefore a purely imaginative light-source.

This term, "mean spherical candle-power," used to denote a quantity of light, is very commonly misunderstood, and is somewhat difficult of explanation, by reason of the imaginary conditions upon which it is based, and the mathematics involved in deriving it; but as the term is much used, and of great importance, it is essential that its true meaning be clearly understood.

As in similar cases, the best way to arrive at a general understanding of the problem will be by the study of a special case. Let us take that of the 16 candle-power electric lamp, which we have already examined in regard to the measurement of its intensity in various directions. In the first place, conceive the spherical candle as a point source giving out rays of one candle-power intensity in every direction. If such a source were placed in the center of a hollow sphere, it would illuminate the interior surface uniformly at every point, with an intensity of illumination depending upon the radius of the sphere. If the sphere were one foot in radius, the surface would have a uniform illumination of one foot-candle. Now imagine the electric lamp in the center of this hollow sphere; it will illumi-

nate the surface with different degrees of intensity at different points. Leaving out of account its variation in a horizontal plane for the sake of simplifying matters, the curve of distribution in the vertical plane will enable us to determine the intensity of illumination on the different parts of the sphere. Thus, around the center, or equator, the intensity of the *light* is 16 candle-power, and the intensity of *illumination*, therefore, 16 foot-candles. At 10 degrees above, and 10 degrees below the horizontal the intensity is also 16 candle-power. The band, or zone, around the sphere extending for 10 degrees each side of the equator, will therefore be illuminated with an intensity of 16 foot-candles.

At 20 degrees above and below the horizontal, the intensity of the rays falls to 15½ candle-power; the intensity of illumination on the zone between 10 and 20 degrees will therefore vary from 15½ to 16 foot-candles. The average, or arithmetical mean of these extremes viz.: 15¾ foot-candles, may be used without sensible error. The average intensity of illumination on all the other zones of 10 degrees in width may be determined in a similar manner.

The question now is, if we could distribute this particular quantity of light *uniformly* over the surface of this imaginary sphere, what would be the resulting *intensity of illumination?* This uniform, or average intensity of illumination is the quantity known as mean spherical candle-power. If we were to actually thus redistribute the light, we would have to take some of the light from the surface near the equator and distribute it over the surface around the poles. It is evident at once that the surface of the zones of 10 degrees in width decreases rapidly as we go from the equator toward the poles; it will, therefore require a proportionately less quantity of light to make a given increase in illumination in the zones near the poles. Thus an average decrease of one candle-power intensity on the zone from the equator to 10 degrees below represents a quantity of light sufficient to illuminate the whole surface of that zone with an intensity of one foot-candle; and it is plain that if this same quantity of light were concentrated upon the small surface comprising the zone extending 10 degrees around the pole, it would raise the intensity of illumination much more than one foot-candle,—as much more as the surface of the zone about the equator is larger than the surface of the zone about the pole: e. g., if the smaller zone had one-fifth the area of the larger one, the *illumination* would be thus increased *five foot-candles*, which would correspond to an increase of five *candle-power* in the average *intensity of the rays* falling on that surface. This shows how great an error it would be to simply take an average of the candle-power intensities at the different angles to represent the mean spherical candle-power, a mistake that is by no means uncommon.

It will be well for the reader to go over this explanation carefully until the distinction between the terms *intensity of light of rays, intensity of illumination, foot-candles, candle-power,* and *quantity of light,* is thoroughly understood.

To return to our example: we can thus divide up the surface of our imaginary sphere into a number of zones, and can find the average intensity of illumination on each of these zones from the curve of distribution of the lamp. We could then actually calculate the areas of these several zones of a sphere of one foot radius, and by multiplying these values by the numbers expressing the corresponding average intensities of illumination we would obtain a number of products which would represent quantities of light since, as we stated at the beginning, quantity of light is proportional to the extent of surface and the intensity of illumination on it. The sum of these products, divided

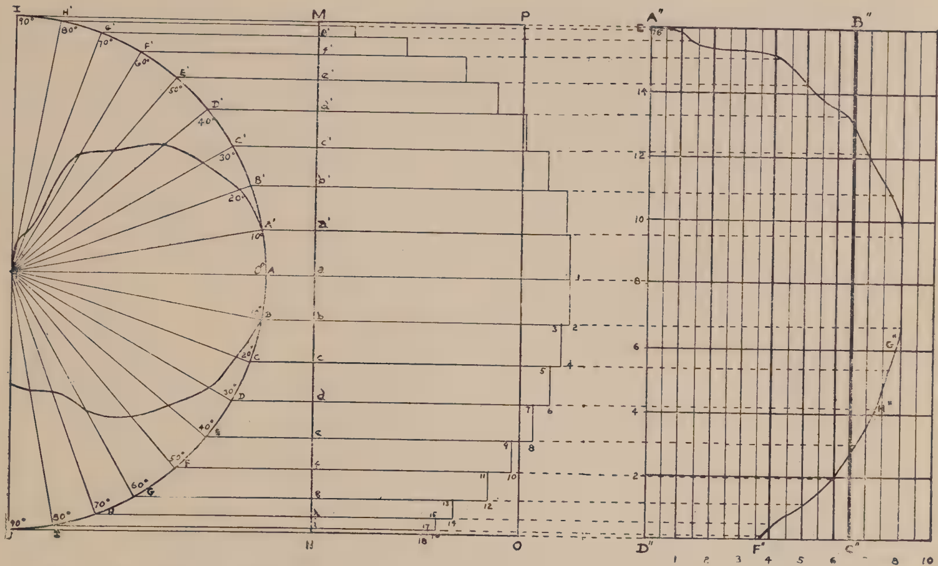

FIG. 1.—METHOD OF DRAWING THE ROUSSEAU CURVE FROM THE CURVE OF DISTRIBUTION.

by the total surface, (i. e., the sum of areas of the several zones) would then give an average intensity of light, which, falling *uniformly* on the entire surface, would represent the same total *quantity* of light as given out by the actual lamp: i. e., the mean spherical candle-power.

The simplest method of carrying out these calculations is by means of a diagram, generally called, from the name of its discoverer, the Rousseau curve. The method is as follows:—

Taking the curve of distribution, draw the vertical line MN parallel to the vertical line of the distribution diagram. Then, from the points where the radial lines meet the outer circle, A, B, C, etc. draw horizontal lines across and beyond the vertical line M-N. It can be proved by mathematics, and we will take it for granted, that the distance between these horizontal lines on the vertical line M-N have the same *relative* values as the surfaces of the zones bounded by the corresponding angles; that is, the distance a-b is as much greater than the distance h-i as the surface of the zone between 0 degree and 10 degrees is greater than the zone between 30 degrees and 40 degrees. If therefore, we multiply these distances by the average intensities of light in the corresponding zones, we will have a number of products representing units of light, from which we can determine the mean spherical candle-power in the manner described above.

The area of a parallelogram is equal to the product of its height and length; if we then take the line a-b as one side of a parallelogram, and, measuring off a distance of 16 units (representing the light intensity) along the line a-1, and use that as the other side, the area of the parallelogram a-1-2-b will represent the product which denotes light-quantity, that is, the quantity of light falling upon the zone between 0 degrees and 10 degrees. In the same manner we may construct the parallelogram b-3-4-c, having the side b-2 15 units long corresponding to the average intensity in the zone between 10 degrees and 20 degrees. The area of this parallelogram will represent the quantity of light falling on that zone; and in a similar manner we can construct a parallelogram for each zone. The

total *area* of these parallelograms will then represent the total *quantity of light* given out by the lamp. If we now draw a single parallelogram of the same total area, having a height M-N equal to the sum of the heights of the several parallelograms, the area of its surface must also represent the same total quantity of light. In order to obtain the length of the other side, M-P, of this parallelogram we need simply to divide the total area by the sum of the heights of the smaller parallelograms, that is, by the length of the line M-N, using the same units of measurement as we used in laying off the horizontal distances. The length of the side M-P then represents the average light intensity necessary to illuminate uniformly the given surface, using the same total quantity of light; in other words, it represents the mean spherical candle-power.

Instead of drawing the parallelograms and using the average intensities for the length of the sides, it is customary to lay off along each horizontal line a distance from the vertical representing the candle-power intensity at that angle, and then draw a curved line through these several points, as shown in Fig. 1. This is the curve referred to as the Rousseau curve. To obtain the mean spherical candle-power it is then necessary to draw a parallelogram which shall have the same area of surface as that included between the curve, the upper and lower horizontal line, and the vertical. This may be done by dividing up the surface into any convenient number of small parallelograms, and finding the sum of the several areas, as above described. A convenient way of doing this is to draw the curve on such a scale that the length of the vertical line is an even number of inches or centimeters, preferably the latter, and then drawing horizontal lines at equal intervals, say of one inch or one centimeter. It is then sufficiently accurate to draw by the eye the side to complete the parallelogram in place of the curved side. Thus, in Fig. 1, in the parallelogram A-B-C-D the line A-B is drawn so that the parallelogram will have the same surface as the figure A-E-F-D; and so on with the other parallelograms. If the paper on which the diagram is drawn has vertical rulings in inches and tenths, or centimeters and millimeters, the calculations then become very simple. All that is necessary is to take the sum of the several horizontal sides, which can be at once counted up on the paper, and divide it by the number of parallelograms; the result will give the length of the side of the single equivalent parallelogram, i.e. the mean spherical candle-power sought.

Attention may now be called to the fundamental difference between the Rousseau curve and the curve of distribution. The former represents the relation between two variable quantities whose product it is desired to know, while the latter represents simply the variation of one quantity with another without regard to any other relation. In reading the former curve, and all others of its class, the *area,* the surface included in the figure is the thing to be considered; while in the latter case it is only the *distance* of any given point on the curve from the center that is significant. The mistake is sometimes made by the layman of assuming, which is rather natural, that the size of the surface bounded by the distribution curve indicates the relative value of the light-source; the comparison of this surface, however, with the surface included in the corresponding Rousseau curve will show how great an error this is. Such an error is particularly large in the case of reflectors giving a highly concentrated light underneath. As already pointed out, a given intensity at the pole, i. e. directly underneath, represents a very much smaller quantity of light than the same intensity about the equator. The Rousseau curve is also useful in showing to the eye the relative total light-powers of different sources.

The Rousseau diagram is sometimes turned around in such a way as to be confusing, at least to those not familiar with it by long use; thus it is sometimes used reversed right and left from the position in which we have shown it, or turned into the horizontal position, that is, with the lines showing the intensities running up and down. These may appear minor and unimportant variations, but it would nevertheless be well if they were avoided. There is really no more necessity or logic in representing horizontal intensity by vertical distances in this case than there would be in so representing them in the distribution curve; and no one would think of such a practice in this case.

In many cases the total amount of light given out above or below the horizontal is required, i. e. the mean lower or upper hemispherical candle-power. This is readily obtained by taking the portion of the Rousseau diagram above or below the horizontal, and treating it in the same manner as described for the entire diagram.

Within recent years a number of photometers have been devised which give the mean spherical candle-power of a light-source with a single reading. These are generally known under the name of "integrating photometers." some of the latest forms of which have been previously described in The Illuminating Engineer. Such instruments are of necessity much larger and more complicated than the simple forms of photometers designed for measurement of light intensity only.

"Intrinsic brilliancy" is the name given to a derived measurement which takes into consideration the intensity of light emitted in relation to the area of luminous surface of the source, and is therefore expressed in candles per square inch, or centimeter. In this case "candles" or "candle-power" means horizontal intensity. The relative brilliancies of the different commercial light-sources are given by Dr. Louis Bell as follows:

The actual measurement of intrinsic brilliancy seldom needs to be made, as it never enters as a numerical factor in any calculations which the illuminating engineer is required to make. In a general way it indicates the extent to which a light produces what is commonly known as "glare," a quality of light which it is highly important to consider, but which does not require mathematical treatment.

Intrinsic Brilliancies in Candle Power Per Square Inch.

Source.	Brilliancy.
Sun in zenith	600,000
Sun at 30 degrees elev.	500,000
Sun on horizon	2,000
Arc light	10,000 to 100,000
Calcium light	5,000
Nernst "glower"	1,000
Incandescent lamp	200-300
Melting platinum	130
Enclosed arc	75-100
Acetylene flame	75-100
Welsbach light	20 to 25
Kerosene light	4 to 8
Candle	3 to 4
Gas flame	3 to 8
Incandescent (frested)	2 to 5
Opal shaded lamps, etc.	0.5 to 2

The intensity of illumination of a surface is expressed, as before stated, in terms of the intensity produced on surface a given distance from a standard light source, the surface being perpendicular to the rays. Knowing the intensity of light rays, it then becomes a simple matter of applying the law of inverse squares to calculate the intensity of illumination upon a surface at any given distance. We have also called attention to the fact that, if the surface illuminated is at other than a right angle to the rays, an additional calculation for this obliquity must be made. The exact mathematical variation of intensity with the angle that the rays make with the surface can only be expressed by means of trigonometry. It is not necessary, however, to be able to solve the problem mathematically in order to make use of the law.

Meters and Meter Reading

By Norman Macbeth.

A great deal of mystery surrounds the subject of electricity, and the measurement of electrical energy in the minds of consumers. Practically all are skeptical of meters and the manner of taking meter statements, or rather the results of meter statements as rendered to them by the electrical company on their monthly bills; and their experience very often serves to strengthen these ideas. A *pro rata,* or averaged bill, increasing the charge when the meter is out of order, is remembered for a much longer time than an allowance on a fast meter, more especially as the consumer receives very few of the latter, and is generally of the opinion that he has been put off half way.

With companies showing a disposition to be fair and liberal, and consumers having a knowledge of the conditions, adjustments can be much more satisfactorily made than in a case which was recently brought to my notice, where a meter on being tested after six months use, was acknowledged to be 15% fast, the company dismissing the inaccuracy with a statement that the meter last year was slow, and if the bill was not paid, the current would be cut off.

While I have seen meters in service running from 50% to 80% fast, these high inaccuracies are unusual—quite as unusual as meters which have stopped, or ceased to register. From the company's standpoint, of course, meters are invariably slow. I am satisfied, however, that carefully tabulated reports from an experience covering a number of meters and a considerable period of time, with meters under different conditions of service, will show that a considerable proportion are frequently fast.

Aside from the ability to read a meter, and decipher the calculations of the average electric bill, consumers should have the protection of a testing bureau of sufficient standing to give them confidence that the treatment accorded them will be impartial. While there is no intention to cast any reflections on the honesty or capacity of the management of the companies, the fact remains that meter men, who have within a very short time tested a meter and through carelessness left it in a bad condition, on further complaint are quite likely to cover their carelessness with a report that the meter is O. K.

I have heard statements from meter men to the effect that they can "throw" any meter test; that is to say, a meter which is incorrect can be tested by them in the presence of the consumer, and they can satisfy him that the meter is correct. Manipulation of a slide rule, a stop watch, or "known resistance" in series with the standard test instruments make this easily possible. I remember a case in a city where a government testing bureau was established, a complaint test on a meter was reported O. K. by the inspector, who had adjusted same within two months previous; this meter without further adjustment was three days later referred to this testing bureau which reported the same to be 7% fast. This inaccuracy was afterwards acknowledged by the Company, due apologies given and allowance made.

In Canada the accuracy of electric meters is passed on by "duly qualified" government inspectors. Every meter is tested by an inspector, and sealed before same may be installed for use. Through the ignorance or connivance of certain inspectors many meters have been passed as being within one or two per cent, three per cent variation being allowed, when actually they were ten or twenty per cent fast. The error in placing a decimal point one place too far to the left, explains how this was done. This particular law does not work out very satisfactorily

for the consumer, as it prevents any one other than a "duly qualified" government inspector from testing a meter with a penalty of $25.00 per meter. This really acts against the consumer as it is the company's privilege to determine whether a meter will register on a two candle-power, four, eight, or sixteen candle-power lamp, and if not to their satisfaction the meter may be removed by them. Checks of this character, of course, would not show whether a meter was fast with twenty-five or thirty lamps on, nor do they come under the specifications of test.

Among other irregularities they permit a meter to be in use five years before a verification is required, and while it is possible to run gas or water meters five, and sometimes ten years, and find same to be within three or four per cent., such ideal conditions are absolutely unknown in electrical meter work where commutators, jewels and permanent retarding magnets have to be reckoned with. Few manufacturers will claim any continued degree of accuracy for their meters under these conditions, and companies who understand the business seldom permit any meter to be out without a verification longer than one year, and for many customers the meters are checked up every three months, or oftener, if desired.

In all fast meter adjustments the company should be compelled to rebate the entire inaccuracy back to the time their last inspection was made. While it is quite possible that a meter that has been in one year, and is found to be 20% fast, has not been fast throughout the entire year, the fact that the company would have to rebate the full period would keep them closer to their meters, with the result that meter departments would receive greater consideration, the meters tested oftener, the inaccuracies would consequently be very much less.

It is not necessary that the consumer should have any particular knowledge of electrical terms, or be capable of going into higher mathematics beyond the appreciation of the fact that a meter which may be 10% slow on two sixteen candle-power lamps does not offset a 10% fast condition on fifty sixteen candle-power lamps. On a ten cent rate, the first would show an undercharge of one-fifth cent per hour where the second would be an overcharge of two and one-half cents per hour. If the load of two lamps was carried for ten hours a day against fifty lamps ten hours a day, the proportion would be two cents undercharge to twenty-five cents overcharge per day, or a net addition of twenty-three cents.

It is not fair to penalize the consumer for a slow meter, as he is in no wise responsible for its condition, and an estimated bill having the effect of increasing the charge 20% to cover a condition of 10% under registration during some period of that month is not just. It may satisfy the electric company management, though they are not losing any money by the transaction.

I remember a case where, from the company's figures of a test, the meter was shown to be approximately 5% slow on full load, and 19% slow at low load; the result of the averaged bill presented for payment would necessiate the meter being 57% slow at average load. This condition, of course, is strictly according to the letter of this company's rules and regulations as provided in their contracts, to the effect, that when meters are out of order, bills may be averaged by the company. Consumers are seldom asked to take a part in this averaging process, nor are they consulted as to whether the period in question was an average, a light, or an exceptionally heavy one.

The object of this article is not to convince the consumer that his electric meter is not accurate, and is not capable of showing a statement of the amount of current used each month, but rather to point out that his meter should be watched and the registrations looked after.

In all cases of short circuits in the house wiring, of sufficient duration to blow the fuses protecting the meter, notify your company and insist on a meter test. More fast meters are caused by short circuits than perhaps any other condition.

All companies are not in the position of a small municipal plant, of which an amusing meter story was written a couple of years ago. One meter was known to be charging several times the correct amount, but the trustees could afford the consumer no relief. They had no method of charging other than by meter, and if they made a deduction on the bill, they were accused of looting the public treasury for political effect. They were unable to engage a meter man to make the necessary repairs, as there was no appropriation in the treasury for that purpose, and the comptroller, being a reformer, stated he would have them indicted for conspiracy if they used money belonging to any other item.

The average consumer is quite as much qualified to read a meter as many electrical men not directly connected with meter work, and so far as the accuracy of a meter is concerned a rough check may be made by turning on eighteen or twenty sixteen candle-power lamps for an hour and noting carefully the amount registered on the meter, which should equal approximately 1,000 watt hours, or one kilowatt hour.

Practically all of the meters in general use to-day are watt hour meters also frequently called integrating or recording watt meters. The dials register the use of electrical energy in watt hours, which term is defined electrically as a current of one ampere flowing under the pressure of one volt for one hour. Bills are ordinarily figured in thousand watt hours, or kilowatt hours, which is practically the result of eighteen to twenty sixteen candle-power lamps, depending on the efficiency of same, burning for one hour, or nine or ten lamps for two hours, etc. An electric meter is an electric motor, the speed of which depends on the amount of energy flowing through same as required for lamps or motors on a consumer's service, and should not register when current devices are not in use. They will register, however, when over compensated or too finely adjusted to overcome the friction of the bearing. The shaft or armature of this motor is in an upright position, the top of same connecting with the gearing on the back of the meter dials. A very small force would cause the armature to rotate very rapidly, and it is necessary to provide some means for governing the speed and the action of same. To accomplish this, permanent magnets are provided between the poles of which a disk, attached to the armature shaft, revolves. These magnets have a break effect on the disk, retarding its speed.

Dials all register in tenths or tens, the lowest reading pointer being the one on the extreme right, facing the meter. It will be seen that the ratio of velocity in the neighboring pointers is ten to one, the wheels of the shaft to the right gearing into the pinion of the shaft just to the left of it. This accounts for the alternate direction of rotation of the pointers. The value of one division on the first dial on the right is one-tenth, the next dial units, the next tens, the next hundreds, and the next thousands. The value of these divisions, however, is placed by different manufacturers at various points. In some meters they are tenths, some units, or quarters, halves, or multiples of ten, as the case may be, according to the constant or dial values as marked on the face of the dial. These values should be determined by a careful consideration of the figures given above or below the dials and with reference to the illustrations following, it is hoped that a fair understanding may be secured. Each dial, you will note, is divided into ten divisions, one revolution of the pointer of any dial is equal to one

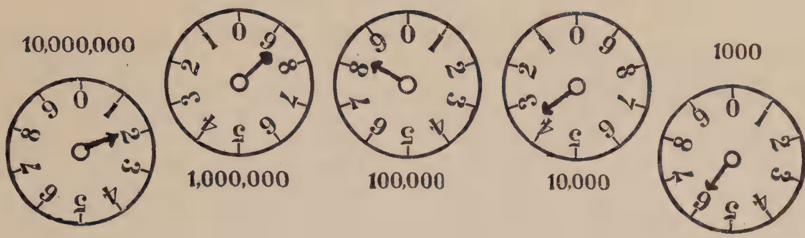

FIG. I.—DIALS OF ELECTRIC METER.

division of the dial of next greater value. Dials are read in the order beginning with that having the lowest capacity, writing the result from right to left. In the reading of the dial shown in figure I, the right-hand dial reads six, the second dial three, being practically six-tenths past three and will not be four until the first dial has reached naught. The third dial reads eight, being three-tenths of a division past eight. The fourth dial reads eight, being eight-tenths of a division past eight, this dial will not read nine until the previous dial reaches naught, which will not occur until the second dial has gone around practically one and six-tenths times, which will require the first dial to go around over sixteen times. The last dial reads one, and can not be two until the next dial to the right reaches naught.

Meter readings are cumulative and always represent total registration from the time the meter was started. To obtain registration for any given period, deduct reading at beginning of period from that at the end, multiply the result by the constant for watt hours, or place a decimal point if the lowest dial reads in tenths, tens, units or parts of units.

Owing to the closeness of the observation required, and the possibility of error caused by the angle at which the observation is taken, it is necessary to read all dials after the first in connection with the one of next lower value. For this reason meter readings should always begin at the right-hand dial.

If a consumer is unable to get a clear understanding of his meter conditions from an electric company's representative owing to the continuous flow of "volts—ampre—watts" talk, he should insist on the use of dollars and cents units with sufficiently plain American to make the explanation clear. There are remarkably few irregular meter conditions which cannot be made plain to the average consumer. Too often for the good of the service complaint agents persist in getting the consumer into the deep waters of technical terms and electrical lore and drowning him.

The consumer is, indeed, in a bad way, who believes that electrical accounting is an exact science, and electric meters above suspicion. Learn to read your meter and devote the same proportion of time to this charge as is given to checking any merchandise bill of similar importance, and you will be amply repaid for the outlay.

(To be Continued)

Daylight Illumination

By Prof. O. H. Basquin.

In the semi-popular treatment of any subject—especially a scientific or technical one—it is generally worth while to spend some time in coming to a definite understanding as to the meaning of some of the words used and to the phenomena to which they refer.

Light is everywhere recognized as the chief essential to the sensation of vision. So common and so widely used as light is, it is quite likely that we shall never be able to draw a clear picture of just what constitutes light. It is known to be a wave-motion in an unknown something called the ether. It roughly resembles the wave passing along the lash of a whip when it is snapped, in that the motion in the wave is at right angles to the direction in which the wave as a whole is traveling.

Of those waves which affect the eye, the short ones appear blue or violet, the long ones red, while those of intermediate length are yellow. The shortest waves seen are roughly half the length of the longest visible.

Still shorter waves are abundant and are studied by photography and the still more abundant longer waves are studied by their heat effects.

Light is generally produced by heating something to a high temperature; the higher the temperature, the brighter the light. In the gas flame the high temperature is reached by combustion and the material heated is thought to be small particles of solid carbon, while in the incandescent lamp the solid filament is heated by the energy lost from an electric current passing through it.

Daylight is generally thought of as something quite different from artificial light, inasmuch as the heated source is commonly not apparent; indeed its immediate source attracts so little attention that one may be quite in doubt as to where it comes from. Daylight is that natural light which begins somewhat before sunrise each day and continues present everywhere in unconfined spaces until some time after sunset. Whether the weather be cloudy or clear the presence of daylight is the most striking characteristic of daytime while night is characterized by its absence.

In clear weather it is evident that our daylight is directly dependent upon sunshine—ordinary light which travels through that great space from the sun to the earth in the same way that light passes from a lamp to the printed page. But we have daylight on the north side of buildings not touched by sunshine, besides throughout a large portion of the time that we have daylight the sun itself is invisible. In order to understand the presence of daylight without sunshine let us spend a moment upon the subject of diffusion.

The filament of a lighted lamp is visible by means of light which originates at the filament. A printed page is visible, not because it gives out light itself, but because it does not take up all the light which falls upon it. A portion of the lamplight thrown off by the paper enters the eye and produces the sensation of vision. The light thrown off by the paper does not contain any waves which were not in the light falling upon it. In general the paper absorbs certain waves so that the light thrown off has generally a different color from the incident light, but its nature is not changed. Light thus thrown off irregularly from a rough surface like unglazed paper is said to be "diffused." A surface giving complete diffusion appears equally bright in all directions. All surfaces which can be clearly seen produce a considerable diffusion in the light striking them.

If one stand between his book and the lamp he can still see the book because the faint light diffused from the walls and ceiling, strikes the book, enabling it in turn to throw off enough light—thus twice diffused—to affect the eyesight. The sensation given by the eye is a rough and ready measure of the light given off by a body. Of two pieces of cloth, that one is said to be the lighter, which throws off in diffusion, as judged by the eye, the greater proportion of incident light. The light diffused from the surface of the full moon is sufficient to enable one, on a clear night, to tell the time by his watch; while the snow in sunshine gives off so much diffused light as to be very painful to the unprotected eye.

It is the diffused light from the ground, trees, buildings and the like that penetrates spaces which the sunshine cannot reach and gives them a subdued and frequently colored light.

Diffused light comes not only from such bodies as paper, cloth and snow but also from finely divided particles in the air, such as dust, smoke and fog. If a ray of sunshine be admitted to an otherwise dark room, its path is made visible by the dust particles which it reveals. Recent years have made us familiar with the white arm of the searchlight, rendered visible by the innumerable tiny floating things, which scatter its light in all directions and thus becomes of particular interest and beauty in the presence of a thin fog or mist.

A fog, however, is nothing but a cloud close to the ground; and it is thus but a step to see that a cloud may appear very bright when sunshine is falling upon it. A cloud is made up of small drops of water or of ice. The sunlight falling on the first layer of drops is probably not diffused but is thrown off in rainbow formation; this light is taken up by other layers in succession and thrown in various directions until finally, when it emerges from the cloud the directions of the light rays are completely mixed up or diffused. The sky overcast with thin clouds is practically uniformly bright in all directions and gives a soft mellow light very agreeable to the eyes, shadows being reduced to a minimum.

Even such a thin medium as the air turns some light aside. Its principal effect is among the shorter blue light waves making the sky between the clouds appear blue in color. For this reason also when the sun is low in the morning and evening its disc appears red because the diagonal path of its rays through the air has then become so great as to take out a very large proportion of the blue and green light, leaving the reddish colors. The illumination from the blue sky is insignificant when compared with that of the clouds.

In summarizing the sources of daylight we may enumerate: (1) sunshine, (2) cloudlight or white skylight derived from scattered sunshine, (3) blue skylight from the air, and (4) diffused light thrown off from objects illuminated from the above sources or from previous diffusions. The discussion of daylight illumination naturally covers methods of estimating the illumination of windows from each of these sources with a study of the distribution of the illumination in rooms under various conditions.

(To be Continued)

The Illumination of the New City Hall, Newark, N. J.

The lighting installation of the city hall of Newark is remarkable from the fact, that there are practically no fixtures used in the entire system. With the exception of a few single gas brackets for emergency lighting, and a matter of a half-dozen electric brackets at the stairway landings, the only fixtures in the entire building are two newel-post standards at the foot of the main stairway in the basement. The illumination in general is entirely from incandescent lamps studded in the ceiling, the general plan of placing the lamps being that of a rectangle in lines parallel to the outline of the room. In no case have lamps above 16 candle-power been provided, and in many of the rooms it was expected that 8 candle-power lamps would be sufficient.

This method of illumination has the undisputed advantage over all others of cheapness of the original installation, and the readiness with which additional illumination may be provided, or repairs made upon the existing system. The majority of the wiring in this case is practically exposed, the conduits being run along the ceiling, with sockets placed at the desired intervals, the whole being covered with a stucco moulding. The method of construction is shown in Fig. 1.

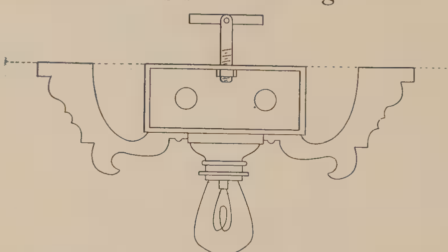

FIG. 1.—SECTION THROUGH MOULDING.

While no reflectors or globes of any kind were originally intended, the mistake so often made in similar kinds of installation, of placing the socket entirely within the moulding, or ceiling, thus preventing the possibility of attaching a reflector has not been made in this case. The sockets project sufficiently below the stucco moulding to permit of a shade holder being attached if desired.

As this is probably the largest public building using this method of lighting exclusively, the results are especially interesting to illuminating engineers. In fact this installation offers opportunities for investigating on a larger scale, the problems which Mr. Millar discussed in his paper presented before the Illuminating Engineering Society, an abstract of which appears in another section of this issue. As it afforded special opportunities for investigating the results to be obtained by the use of reflectors with ceiling lamps, we had illuminometer measurements made for this purpose in two of the smaller rooms, the results of which are given in the accompanying diagrams, Figs. 2, 3, and 4. Room A is 24 feet long by 14½ feet wide, and has 22 lamps installed. Room B is the same length, but 1 foot wider, and has 20 lamps. The ceiling is 15½ ft. high. A frieze of light buff tint 4½ ft. wide runs about the side walls. It was not noticed until after the tests had been made, that the rooms varied slightly in width, and that room A contained two more lamps than room B. But these variations are not large enough to materially affect the general results for purposes of comparison.

The illumination on a horizontal plane at the height of an ordinary desk (30 inches) was taken at the center of the room, and at a point directly under the row of lamps midway between the side walls.

Two measurements were taken in room A. First with bare 8 candle-power oval anchored filament lamps, the second with the same lamps fitted with Holophane prismatic reflectors (No. 2631). The curves of illumination are given in Fig. 2.

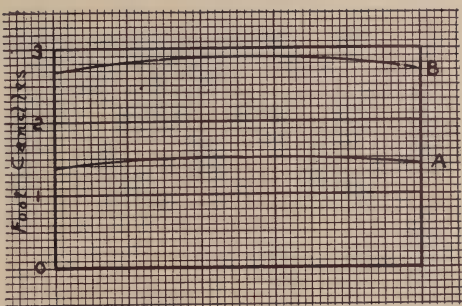

FIG. 2.—CURVES OF ILLUMINATION ON A LINE LENGTHWISE IN ROOM A. CURVE A, BARE 8 CP. LAMPS; CURVE B, SAME WITH HOLOPHANE REFLECTORS.

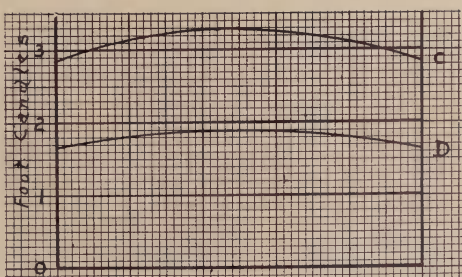

FIG. 3.—CURVES OF ILLUMINATION ON A LINE LENGTHWISE IN ROOM B, CURVE C, BARE 16 CP. LAMPS; CURVE D, 8 CP. LAMPS WITH ENAMELED REFLECTORS.

Two tests were also made in room B; the first with 8 candle-power oval anchored filament clear lamps, fitted with small "diffusing" (white enameled prismatic glass) reflectors, and the second with bare 16 candle-power oval anchored filament lamps. The results obtained are shown in Fig. 3.

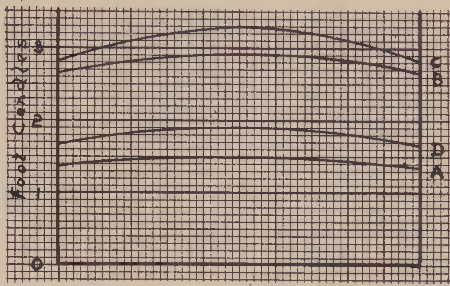

FIG. 4.—COMPARISON OF CURVES OF ILLUMINATION IN ROOMS A. AND B.

As before stated, the similarity of conditions is so close as to render the tests in the two rooms comparable As room A contained 10 per cent more lamps, the values obtained have been reduced 10 per cent., and compared with the values obtained in room B, in Fig. 4. This comparison shows that the illumination on the useful plane is practically doubled by the use of the prismatic reflector; that diffusing reflectors increase the illumination about 20 per cent. and that 16 candle-power bare lamps give 10 per cent more illumination than 8 candle-power lamps equipped with prismatic reflectors. It should be noted, however, in this case, that the ceilings are high relative to the size of the room, which gives an advantage to reflectors giving a more concentrated, downward distribution, and also that the Holophane reflectors used were of larger diameter than the diffusing reflectors.

One of the larger rooms of the building is shown in plan, in Fig. 5, the position of the lamps on the ceiling being also indicated. It will be seen that the lamps are comparatively very close to the side walls. A heavy moulding runs about the side walls just below the lamps, which has been tinted a dark drab. The side walls are of a similar cast; the ceiling in light buff. The dotted lines indicate beams running across the ceiling, dividing it into five panels. There are 16 candle-power clear oval anchored filament lamps at present installed.

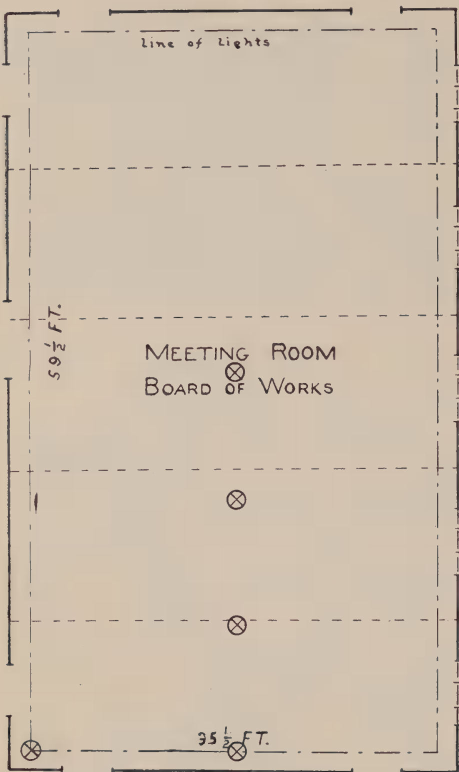

FIG. 5.—PLAN OF ROOM, SHOWING POSITION OF LAMPS AND POINTS AT WHICH ILLUMINOMETER MEASUREMENTS WERE MADE.

It would at once be assumed from an inspection of this arrangement that a very unequal distribution of illumination would be the result. The inequality, however, as shown by actual measurement, proves to be much less than might be expected. Measurements were taken in the four positions, indicated in the diagram Fig. 5; the curve of illumination is shown in Fig. 6.

Even with this unequal spacing of the lamps on the ceiling, the difference between the maximum and minimum illumination is much less than is frequently found in the case of illumination by chandeliers. While the minimum intensity (i. e. at the center of the room), is sufficient to permit reading of ordinary print, with a fair degree of readiness, it is hardly satisfactory for the purpose of the room, which is the public meeting place of the Board of Water Commissioners. Owing to the construction used, however, this defect may be very readily corrected by the simple expedient of installing rows of lamps in each of the panels. With this additional installment, and by the use of reflectors, the room can be amply illuminated by the use of 8 candle-power lamps.

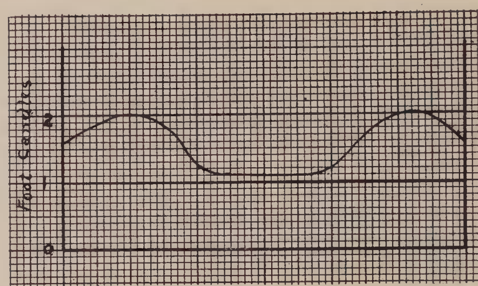

FIG. 6.—CURVE OF ILLUMINATION, BOARD OF WORKS ROOM.

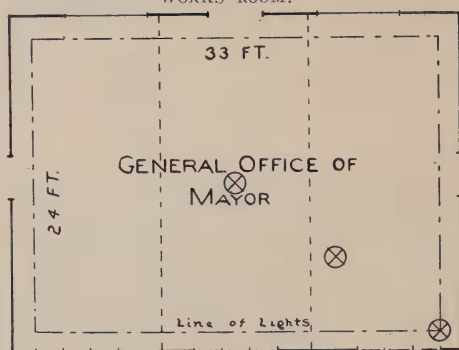

FIG. 7.—CEILING PLAN, MAYOR'S ROOM.

The ceiling plan of the Mayor's room is shown in Fig. 7. The dotted lines indicate beams dividing the ceiling into three pannels. The general color scheme of ceiling and walls is drab and buff. The lamps installed are clear, oval anchored filament, 16 candle-power. Measurements of illumination were taken on a semi-diagonal of the room, as indicated in the diagram, and the curve of illumination is given in Fig. 10. It will be seen that the illumination is satisfactory as to uniformity, and of ample intensity without being excessive.

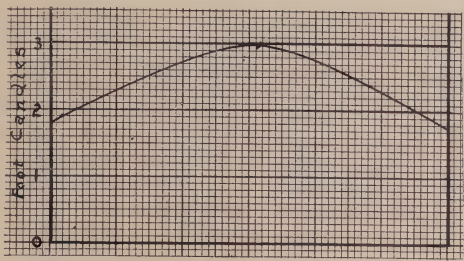

FIG. 8.—CURVE OF ILLUMINATION ON A LINE DIAGONALLY ACROSS MAYOR'S ROOM.

The one room in which the system installed proves to be wholly unsatisfactory is the Council Chamber. This is shown in plan, in Fig. 9. At the front there is a platform as shown, the portion intended for the presiding officer raised 30 inches from the floor level. The recess back of this platform forms a segment of a dome at a height of about 20 feet from the platform. At the base of this dome-shaped ceiling, a cornice is provided, behind which is placed a row of 16 candle-power lamps. The ceiling of the dome above is gilded.

The general ceiling plan is shown in Fig. 9. Lamps are placed in the dental course of the moulding joining the ceiling and side walls. It will be noted that the lamps are omitted along the front side of the room. The dome is constructed of leaded glass of a very slight opalescence. There is a space of three or four feet above the top of this dome, and the sky-light in the roof. A circle of 16 candle-power

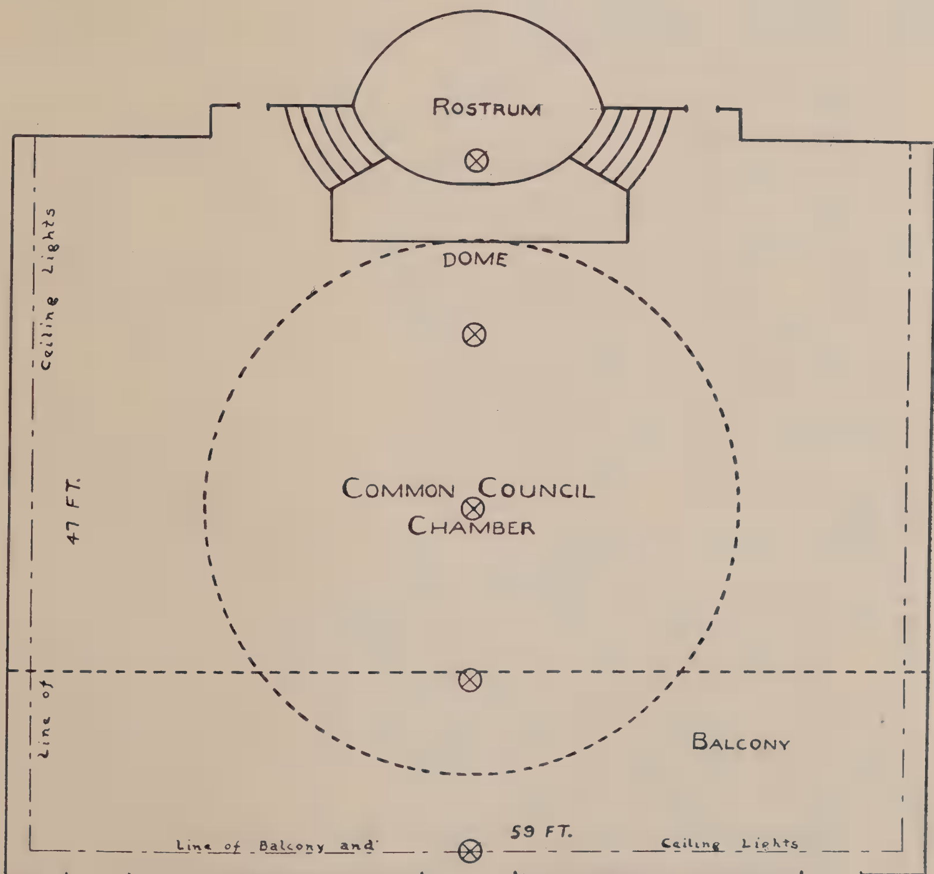

FIG. 9.—PLAN OF COUNCIL CHAMBER.

lamps is placed above the dome in the position indicated on the plan. The height of the ceiling is about 20 feet. Illuminometer measurements made on a horizontal plane 30 inches above the floor at the points indicated in Fig. 9 gave the results shown in the curve, Fig. 10.

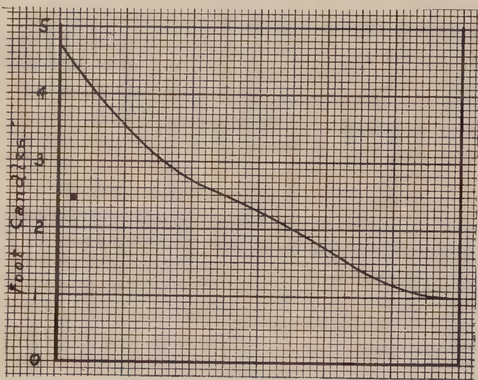

FIG. 10.—CURVE OF ILLUMINATION ON LINE ACROSS COUNCIL CHAMBER.

It will be seen that while the illumination at the extreme rear of the room is excessive, in the front portion, and especially on the platforms, where illumination is mostly needed, it is entirely too low for purposes of reading or writing. An architectural feature of the room in this case, however, fortunately offers a very satisfactory means of supplying the requisite illumination in this space. The dome in the ceiling is sufficiently large, and the glass entirely suitable for permitting an illumination of the space below by means of light sources placed above. It would seem to offer a peculiarly fitting case for the use of a flaming arc lamp for interior lighting. By placing such an arc, fitted with a reflector which would restrict the light to the glass surface of the dome, a beautiful, soft illumination, harmonizing perfectly in color with the incandescent lamps within, could be projected into the space below. The two possible objections to the flaming arc for interior illumination, viz.: the presence of fumes, and a slight flickering, common to all arc lamps, would scarcely be objectionable in this case. The fumes would be entirely excluded from the room by the ceiling and dome, and the slight flickering would be so distributed by reason of the diffusion of the glass, and counterbalanced by the illumination of the incandescent lamps, as probably not to be appreciable. The dome of the rotunda could be improved in appearance by the same method; although the illumination in this case is now ample for all requirements.

The principal corridors of the different floors run around the interior court. The illumination provided for these, consists of a double row of lamps in the ceiling. These are arranged at the switchboard, so that either row can be turned on separately also alternating lamps in either row. This furnishes a method of illuminating the corridor with several degrees of intensity, which is entirely satisfactory.

From an optical standpoint, one fault can be laid against the system as carried out in this case, and that is the presence of bare lamps. This optical objection can undoubtedly, be removed within a comparatively short time without any increase in the maintenance cost by the use of the new metal filament lamps.

From the decorative standpoint, a clear lamp without any form of shade or reflector, looks bare and unfinished.

In order to compare the efficiency of illumination by this method with that of other methods the following figures as to the watts per square foot of floor surface, will be instructive:

Room.	Watts per sq. ft.
A (8 cp. lamps)	2.0
B (16. cp. lamps)	3.2
Mayor's	4.8
Board of Works	2.1
Council Chamber	4.8

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THE ILLUMINATING ENGINEERING SOCIETY

It is now practically a year since the inception of the movement to form a society of Illuminating Engineers. The call for the first meeting was sent out on December 13th, 1905. Within the space of twelve months a national organization has been formed, with a membership of more than 850, and active branches in four of the largest cities, exclusive of the branch in New York, viz.: Chicago, Philadelphia, Boston and Pittsburgh.

Some recent philosopher has said, that the way to start a society of any kind was to issue a call for a meeting for the purpose of organization, and then for everybody to wait and see who joined before becoming members themselves. This method of procedure, which is only too commonly practiced, was, fortunately, not followed in the history of the Illuminating Engineering Society. A surprisingly large number of those whose presence was solicited for the first meeting responded by personal attendance, and nearly all of the others by letter; and from the very beginning the interest in the formation of the society and the work which it set out to accomplish amounted to positive enthusiasm. The few who doubted the expediency of forming such a society, either from a belief that the time was not yet ripe, or from a fear that the preserves of the older societies and professions might be trespassed upon, were early convinced of the error of their ways. In fact the society has grown both in membership and importance beyond the most sanguine expectation of its early promotors.

The value of the membership of such a society, however, is not adequately expressed by mere numbers alone. Quality counts even more than quantity. In this respect the Illuminating Engineering Society is second to none of the established technical societies, its membership including practically all of those who are most closely identified with the production and use of light, both in the theoretical and practical fields.

The considerable number of members who, either by reason of their distance from the regulation meeting places of the several branches, or the multitude of duties incident to their positions, cannot expect to personally attend the meetings; is a demonstration of their appreciation of the value and importance of the work to be accomplished by the society, and the duty of lending their moral support and financial assistance to its promotion.

The excellent progress thus far made, should give an impetus to the work of still further extending the membership and sphere of usefulness of the society. The council are especially anxious to bring the membership up to a thousand before the annual meeting in January. Even one thousand is a very small minority of those vitally interested in the subject of illumination in this country. There is one field in particular which is very inadequately represented, and that is the architects. The architect is, at least in the public mind, held responsible for all of the results and effects obtained in a building, and, even though he may employ an electrical

or other engineer to supervise the lighting installation, any defects in results will be ascribed to the architect to his discredit. And even though he may employ an illuminating engineer for the purpose, it behooves the architect to become sufficiently familiar with the general principles of the subject, and the best possible results obtainable, to check up intelligently the work of the engineer. Furthermore, it is high time that the architect should recognize the fact, and endeavor to impress it upon his client, that the illumination of a building is an exceedingly important item in its equipment, and well worth the attention of a specialist, even at the cost of a reasonable additional fee. In no way can the architect further the general progress and recognition of illumination as an engineering problem, than by identifying himself with the Illuminating Engineering Society; and it is earnestly to be hoped that this most important profession may have an adequate representation among its members.

But, mere membership alone does not make a technical society. The prime purpose of such a society is to stimulate research and investigation, and to disseminate knowledge. The subject of illuminating engineering is comparatively a virgin field for such work; and especially those engineers actively engaged in the work of illumination should consider it a duty to their colleagues to embody the methods used in the various problems, and the results obtained in communications to the society. The papers thus far presented have been highly creditable, especially considering the imperfect state of the science, and the recent organization of the society. But if the work of the society is to prove of continual and increasing value to its members, the matter of the papers presented must be given particular attention, not only by the committee having it in charge, but by the entire membership. No delicacy need be felt in volunteering papers. Such communications will be always in order and welcome. Any information regarding membership, papers, or other matters pertaining to the society, will be cheerfully given by application to the secretary, Dr. A. H. Elliott, 4 Irving place, N. Y. City.

MEAN SPHERICAL CANDLE-POWER AND ITS MEASUREMENTS

The importance of determining the total flux of light emitted by the various sources, or, to use the cumbersome term that has come into general use, "mean spherical candle-power," has long been recognized by scientists; but those most concerned with the practical use of light have been slow to appreciate its value.

The two chief obstacles in the way of the more common use of this all-important measurement are, the difficulties that have attended the making of the measurement, and that complicated process by which the final results have been derived, this rendering the meaning of the measurement difficult of comprehension by the layman. It is even difficult to formulate a definition of "mean spherical candle-power," that can be intelligently followed by the non-technical reader.

In view of these undisputed objections to the use of this fundamentally important measurement, there should be concerted action on the part of the scientific societies, and the producers of light and lighting apparatus, looking toward the establishment of some more simple and definite system of photometric units. A joint committee from the Illuminating Engineering Society, the American Institution of Electrical Engineers, and the newly formed Gas Institute, might accomplish something in this direction.

The long and tedious process of making a series of measurements of intensity in different directions, plotting the curve of distribution, deriving the Rousseau curve from this, and then integrating the Rousseau curve, has rendered the method prohibitive except for purpose of special scientific

investigation. In the case of the arc lamp, in which the intensity in different directions varies almost continuously, the process has given an approximation, rather than a true measurement.

The value of an instrument by which the total flux can be accurately measured by a single reading is, therefore, self-evident. Blondel produced an instrument of this kind in 1895, which he called a "Lumenmeter." It was designed especially for the measurement of arc lamps. Some years later, Prof. Mathews constructed an "Integrating Photometer," primarily designed for measuring the mean spherical candle-power of incandescent electric lamps, although it has since been adopted to arc light photometry. The apparatus has been improved and put on the market at a reasonable price, considering its necessarily somewhat elaborate construction.

More recently German photometricians have been developing a form of instrument which they call a "globe photometer," and which promises to furnish a practical solution to this vexing problem. The general principle of this instrument is a hollow globe, the interior of which has a white matt surface forming a diffuse reflector. The illumination on a small portion of the surface, which is defined by an opening or window into the globe, is then measured in the same manner as a light source. The instrument is calibrated by comparing the values thus obtained with the spherical or hemispherical intensity derived by the usual methods. Both theory and the construction of the instrument have been carefully investigated by various German scientists, the results of several of these investigations having been previously given in the Illuminating Engineer.

The instrument seems to be reasonably cheap to construct, and by taking the precautions which have been pointed out by the different investigators, capable of results which are well within the limits of accuracy requisite for commercial work. It would seem that such an instrument would afford especially good means for measuring the flux of arc lamps, since changes in the position of the arc upon the carbons, which renders the measurements of intensity in given directions so unreliable, would have no effect in this instrument. It is worth mentioning that the standardizing committee appointed by the German electrical manufacturers, and Electrical Engineers Association, have recommended the use of an instrument of this form for determining the hemispherical candle-power by which arc lamps are to be rated. With a practical and cheap form of photometer by which spherical intensity can be obtained by a single measurement as easily as intensity in one direction is measured on the ordinary photometer, there is no sufficient reason for further following the illogical and unscientific practice of rating light surfaces by intensity in one direction.

On the subject of spherical measurements, however, there seems to be a tendency to substitute a new error for the old one; namely, of considering only the lower hemispherical intensity, or candle-power. It is argued that the only light utilized for producing illumination under ordinary conditions is that which falls below the plane of the light surface. The fact may be accepted as self-evident, but it by no means follows that the rating of a light-source by the hemispherical intensity affords a sufficient statement of its values. A light-source which threw all of its light into the upper hemisphere, would, according to this method, have no value, that is, an efficiency of zero, which is manifestly absurd; by the simple use of a reflector, the upward light can be distributed practically at will in any direction below, or elsewhere.

There are three quantities which the Illuminating Engineer needs to know in order to intelligently handle any given form of light source:

1st—The total quantity of light given out for a given expenditure of energy.

2d—The natural distribution of intensity in a vertical plane, with the light source in its normal position.

3d—The distribution, or total flux of light, that can be produced on a given area by the use of the best accessory with which the light source can be fitted.

The first quantity gives the absolute efficiency, and shows what proportion of the total energy supplied is converted into light.

The second shows for what purpose the light source is suitable for use without any accessories, and also gives necessary data for designing accessories, such as reflectors and globes.

The third gives the efficiency of the light unit, that is, the light source and its accessories, for any given purpose of illumination.

The first measurement is the proper one for the commercial rating of the light source, since it is invariable; the second and third measurements may be dependent upon the special use to which the illumination is to be put, and upon the skill of the designer of the accessories; and the Illuminating Engineer is quite as responsible for such design as the manufacturers.

THE RELATIVE IMPORTANCE OF ILLUMINATING ENGINEERING

Under the title of "Design, Installation and Maintenance of the Modern Office Building," a writer who uses the title of C. E. after his name discusses at length in an article, running through two issues of the *Journal of the Franklin Institute*, the various problems included in the comprehensive title of his article.

He evidently intended to omit no detail which should be considered in the construction of a modern office building of the highest class. A careful examination of his paper, however, failed to discover the slightest reference to artificial illumination. A reasonable explanation of such an omission is hard to find, and still harder to justify. It throws much light, metaphorically speaking, upon the well recognized fact that the artificial illumination provided in the average office building is unsatisfactory and woefully inefficient and behind the times as compared with the other utilities provided for. If a specialist in dealing with the various points of construction and facilities to be provided has so little consideration for the matter of illumination as to think it unworthy of so much as a mere mention, what sort of results are to be expected? And who is to supply this inferentially trifling omission?

The fact still remains, however, that artificial light must be provided in every office, passage-way, and space in the building; and the necessary plant for supplying this light is one of the largest items in the equipment of the building, and supplying the light one of the largest items of maintenance. And yet this engineer, presumably of good standing in his profession, apparently does not consider it worthy of notice!

The seat of the trouble, however, lies in the general ignorance of the public on matters of illumination. Poor illumination is so common, or rather good illumination so rare, that it is taken as a matter of course that artificial lighting must be "hard to work by," or "hard on the eyes," and so only the extremes of defective illumination bring forth any protest on the part of the user. The owners of office buildings are as careless of the importance of artificial illumination as are the engineers. In setting forth the advantages of such a building, as is frequently done in brochures most elaborately gotten up, who has ever seen the excellence of the artificial illuminating system set forth as one of the advantages? And yet, even in the best lighted buildings, there are of necessity a great number of offices in which the daylight illumination is of only moderate intensity at the best.

and in which, at least during the shorter days of the year, artificial illumination must furnish the actual working light, to say nothing of the growing tendency to extend work into the night. If an amount of care in the designing and installation of the illuminating equipment were given proportionate to its importance, and the fact demonstrated to prospective tenants, it would be one of the most attractive features that could possibly be provided.

In the campaign of education to which the illuminating engineer must devote a considerable proportion of his energies for some years to come, the owner must receive a large share of attention, since he is the court of highest appeal in deciding upon the equipment of the building. Next to the owner the architect should be worked with. As a mere matter of business the architect naturally wishes to satisfy his client; but so long as his clients do not especially demand a high quality and efficiency of illumination, the architect cannot be censured too severely for not educating his client up to the point of making such demands.

In the case of public buildings, such as office buildings, it is possible to go one step further back, and show the tenant the difference between good and poor illumination; for ultimately it is the demand of the tenant that must determine the character of the utilities to be offered. The article cited at the beginning of our discussion brings before us forcibly the fact that much missionary work remains still to be done before illuminating engineering becomes a generally accepted and utilized branch of applied science.

"STANDARDIZED MEDIOCRITY"

Under the above title the Industrial Supplement of the (London) *Electrician* comments upon a recent article by Dr. Louis Bell in the *Engineering Magazine.*

The editorial starts out by stating that "America is generally recognized today as the land of standardization. The word manufacturer there means nothing more nor less than concentrated production. The automatic multiplication of parts, and their hurried assembly into an article of commerce constitutes the American method of which we have heard and are hearing so much."

"The land of standardization" is a particularly happy characterization of American civilization. *The Electrician* admits that this policy has resulted in bringing American manufactures to a wonderfully high degree of commercial supremacy, and very pertinently asks the question: "Can it last? Will not America find that in hastening to the front she has confiscated her right to recognition by the adoption of methods apparently brilliant and effective, but in reality slovenly and incongruous?" It is possible to get too much even of a good thing; and the advantages of standardization have their limits. In a general sense standardization is opposed to originality. It has been generally admitted, often somewhat boastfully, by Americans, that while Europeans may lead in scientific discoveries, it takes the Americans to reduce these theories to practical results.

While such a standardization of original discoveries may have its advantages commercially, it would be an unquestioned injury to progress in general if such a course tended to suppress or stunt the growth of original discovery and invention. The recent remarkable progress in methods of producing light, particularly from the electric current, would seem to indicate that such a condition has been reached in this country. Practically all of the research work which has resulted in these improvements has been done by Europeans. The discoveries of Welsbach revolutionized gas lighting and saved it from practical annihilation at the hands of electric illumination. The inverted gas burner, air hole chimneys, and flexible mantles

are likewise of European origin. The theoretical basis of the mercury vapor lamp and the use of the rare earths in the production of electric light as exemplified in the Nernst lamp, are likewise of German origin. So also is the theoretical and practical development of the flaming arc lamp, and more recently the use of the rare-metal filament, as employed in the Tantalum and Tungsten lamps, and which are apparently destined to supersede the carbon filament lamp, are German and Austrian discoveries. Even the theoretical work upon which the enclosed arc lamp was based must be credited to Europeans, and for some time after the commercial introduction of the enclosed arc in this country we were obliged to go to Germany for our carbons, and large quantities of imported carbons are still used.

In this particular field, therefore, it is evident that we are being completely outclassed by the European. The difficulties of obtaining intelligent skilled labor in this country are universally acknowledged by those who have in any way come in contact with the problem, and the difficulties seem to be increasing rather than diminishing. This may be ascribed to several causes, among which are the tremendous strides that have been made toward consolidation and standardization, which applies not only to machinery, but to workmen as well. As the manufacturing concern has become larger the individual workman has become relatively smaller, until in many of the great aggregations that comprise the modern industrial concern of today the individual workman is practically no more than one of the thousands of parts in a vast machine. Thus not only is the opportunity, but the incentive to individual effort suppressed. As Dr. Bell puts it, "American methods and workmen produce average results of remarkable excellence; but if one wants a bit of work done with the utmost thoroughness and precision, nineteen times out of twenty he will find that the workman who has finished it is a German, or Swede, or Englishman." The reduction of our manufactured products to a condition of "standardized mediocrity," can have no other ultimate effect than reducing the workman to the same condition, the results of which must have a far-reaching effect upon our national civilization.

We take much pride in our ability to adapt European inventions to our own conditions. In many cases this process consists in replacing fine workmanship with clumsy strength, so as to render the device as nearly "fool-proof" as possible—to use a common and expressive term. Mechanical apparatus in common use in Europe is often found to be entirely too delicate for American use. Some years ago an American firm put upon the market an imported arc lamp of German manufacture. Electrically and mechanically the lamp was an almost perfect piece of mechanism; but experience soon proved that the lamp could not be handled by the American public, and the manufacturers were compelled to re-design it so that it would stand American usage.

On all articles which require refined and intelligent hand labor it will be found that the European far excels us and maintains his hold upon our markets, even in spite of the tariff handicap. Thus the finest ornamental glass-ware, that is, glass-ware in which the pieces have the impress of individuality of the workman, is of German or Austrian manufacture; but when it comes to mechanically stamping out imitations of this work, especially of cut glass, by the million pieces, then the American is without a competitor.

Standardization has its value, as do methods of cheap and rapid duplication; but in the end it is the new thought, the original discovery, the true invention, that determines the supremacy of a people, both intellectually and commercially.

Facts and Fancies

THE LIGHTS O' NEW YORK

Commissioner Ellison, of the Dept. of Water Supply, Gas, and Electricity, says the history of lighting the City of New York began in 1821.

"Up to that time New York was lighted by candle or oil lamps, many of which were maintained by citizens. In 1856 gas lamps were put in, and in 1882 electricity, but the system was crude at first. The last of the old-fashioned lamps will be done away with this year, and the streets will be illuminated by arc lights and mantle gas lamps."

He also states that it cost $3,500,000 for lighting the city for the year, but that $800,000 was saved on contracts. The city has 65,818 lights to illuminate 209,918 acres. These are equivalent to 24,000,000 candles. There are 13,987 arc lamps, 4,581 incandescent lamps and 52,957 gas lamps. On the outskirts are 4,183 naphtha lamps, and in Tottenville 100 kerosene lamps have survived modern illumination. The city has 1,380 city buildings to be lighted, requiring 224,294 gas lights and 185,263 electric lights.

FACT, OR FANCY?

A South Dakota newspaper has the following news item, which may properly be classed under the heading, "important if true:"

It has also been left to a South Dakota farmer to discover that enough electricity may be taken from the air above the Buttes to furnish the power which will run electric lights, threshing machines and water pumps.

Such a discovery is one of the marvels of the electrical world, and a dream of inventors for decades, but John H. Stranhan, son of a well-to-do farmer, near Miller, S. D., has made the discovery, and from Sully Buttes may be seen a number of tandem box kites, while half way to the earth, on a No. 8 copper wire, hangs a strange white box the size of a beehive.

From the copper wires which descend from this box enough electrical energy is secured to run the motors with which the Stranhan home is lighted; a feed grinder and threshing machine operated, and a big electrical pump which pours water into the irrigating ditches.

Young Stranhan is a graduate of an Eastern polytechnical school, where he went to complete his studies after graduating from the University of Nebraska, in Lincoln. Since leaving the school he has devoted much of his time to studying the Hertzian waves, the electrical waves which make the wireless telegraph possible. He has experimented under the belief that it was possible to collect the electricity in the air and use it for commercial purposes.

He now declares he has perfected a device which gives him the first current from the air about Sully Buttes, and by a series of inductions the power is increased until it runs all the machinery on the Stranhan farm.

Stranhan says that his scheme was successful from the start, so far as the production of an electrical current was concerned, but that the difficulty was in producing a current of sufficient potentiality to be of utility in farm work. After months of study and experimentation, however, he says that he hit upon a simple device which answered the requirements, and that now he is able to secure from the clouds a current sufficiently strong to run a 20-horse power motor. He says that by increasing the size of his collector he is confident that he will be able to produce currents of practically unlimited power.

A NEW METHOD OF MEASURING THE HEIGHT OF CLOUDS

Mr. J. Palisa, in a recent article in the *Electrotechniker,* describes a novel method of determining the height of clouds, which was first suggested by the light from the newly erected electric fountain in Vienna. The method is so simple that, as he aptly says, it is curious that it has not been thought of before, since any good search light would answer the purpose even better than the illuminated fountain. The method is thus described by Palisa:

When the illuminating tests of the new high-pressure fountain in the Schwartzenbergplatz were made, a remarkable cone of light was observed, appearing as though projected from a search light. When this beam of light fell upon a cloud an exceedingly bright spot appeared in the heavens. Dr. J. Rhaden, Assistant at the Vienna Observatory, observing the angle which the

bright spot made with the horizon, conceived the happy thought of using it to determine the height of the clouds.

There is no need of extended geometrical knowledge in order to understand the principles of this procedure. Let us assume that the place of observation (in this case the Observatory) and the fountain are on a level, and that the rays of light ascend vertically. Then let the three points, viz: the Observatory, the fountain, and the spot of light on the cloud, be connected by imaginary lines. A triangle is thus formed of which the base, which is the distance from the Observatory to the fountain, can be easily determined by reference to a correct map of the city. The angle of the beam of light at the fountain is a right angle, and the angle of observation at the Observatory is variable, and to be determined by measurement; the higher the cloud the higher will the spot of light appear and the greater will be this angle of observation. This triangle is shown in Fig. 1, in which *O* represents the Observatory, *F* the fountain, and *C* the spot of light on the cloud. The length of the side *FC* of this triangle, which represents the height of the cloud, may now be easily found by drawing the triangle to scale, or more accurately, by a trigonometrical formula.

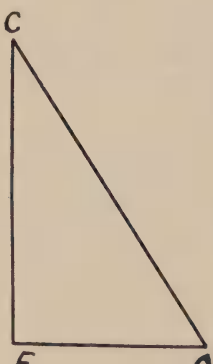


FIG. 1.

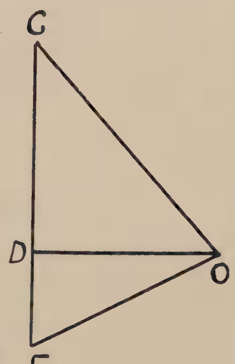


FIG. 2.

As a matter of fact, the fountain and the observatory are not on the same level, but this does not seriously complicate the problem. Draw the triangle Fig. 2, in which the points *CFO* will be respectively the light spot, the fountain, and the observatory, as in Fig. 1. This is not a right-angle triangle, but may be divided into two right-angle triangles by drawing the line *OD*, representing a horizontal light from the observatory to the beam of light. The upper of these two triangles can now be solved by the method already described. The lower triangle is constant, and can be solved once for all; the side *OF* is the actual distance from the Observatory to the fountain, and the side *FD* is the difference in levels between the fountain and Observatory, which is 71m. The height *FC* will then be the sum of the heights of the two triangles.

It is evident that in case of several stratum can be observed; but if a rift occurs in the lower stratum and this crosses the beam of light, a spot will appear on the upper stratum, an event which repeatedly happened during recent observations. It will be noted however that the higher the stratum the fainter will be the light spot.

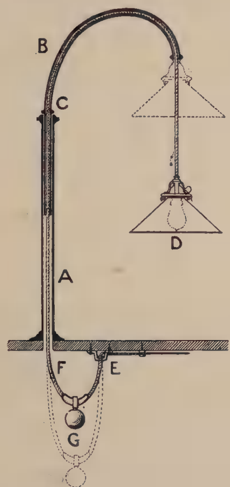
A number of observations show cloud heights varying from 1550 to 10,070 meters (one to six miles).

It is peculiar that during apparently perfectly clear weather a bright spot will sometimes appear in the projection of the beam of light, showing the presence of a stratum of fine vapor, ordinary visible with difficulty, or entirely invisible. On one occasion this vapor stratum proved to be more than 10,000 m. high.

As far as known no attention has heretofore been given to the observation of cloud heights at night, as observations by day have offered great difficulties. In order to carry out such observations by day the angle between certain points on the clouds and the horizon must be measured at two different places the distance between which is known. On account of the rapid change of clouds such measurements must be made simultaneously at both places. This would seem to be easily accomplished by the observers setting their watches beforehand and agreeing upon the time of observation. That the same position of clouds will be noted by both observers, however, is extremely difficult, in fact impossible. The best results thus far obtained have been by each observer directing a camera to the zenith and at the time agreed upon making a quick exposure. By means of the photographs thus taken the exact points used for measurement of the clouds may be seen and by means of proper calculations the positions of these points determined. This new method using a beam of light, is astonishing on account of its sheer simplicity, and it is really to be wondered at that the idea was not conceived before. It is evident that the knowledge of this method can be of great value to the science of meteorology and in pursuance of other investigations.

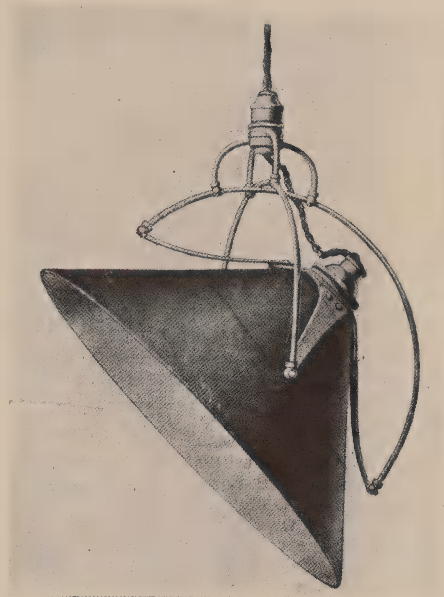
DESK LIGHTING

A satisfactory method of desk lighting, at least one having universal approval, does not seem to have been yet produced. The illustrations show two efforts in this line from foreign sources. The first illustration shows a design for adjusting the height, and also, within a certain radius, the position of a desk lamp. This device is of German origin.



ADJUSTABLE DESK LIGHT FIXTURE

In the English market is to be found a device for tilting a reflector into any desired position. If this were applied to the German arrangement it would produce practically a universally adjustable lamp and reflector; and if the fixture were placed on the desk



ADJUSTABLE REFLECTOR

as shown it would be possible to secure almost any position of light-source and direction of rays desired.

Another device for this purpose which has lately been put upon the English market is shown in the illustration below. It consists of an incandescent electric lamp made in the form of a long tube with a filament running from one end to the other.

ADJUSTABLE FIXTURE IN USE

TUBULAR LAMP AND REFLECTOR

FIXTURES IN BOXES TO TAKE HOME

If there is another thing besides "standardization" that characterizes American manufacturers it is the wide use and general excellence of the packages in which manufactured articles are put up. In this respect America easily leads the world.

A handsome package appeals to the buyer in several ways. The package may be gotten up in so tasty a manner as to be an attraction in itself; then, there is the charm and satisfaction of receiving the goods exactly as they left the hands of the manufacturer, with the certain knowledge that they have not been handled or tampered with by others. To the merchant there is the convenience of having the goods securely done up and ready to hand out to the customer.

The idea of putting up a lighting fixture, with all the necessary accessories and fittings, in a package ready for the user, is original with the Cleveland Gas & Electric Fixture Co., who are putting up a line of gas and electric fixtures of the simpler designs that are most frequently used, in neat paste board cartons ready for the customer, gas-fitter, or electrician. The many advantages which apply to the original package apply fully in this case, and the company mentioned deserve, and will no doubt receive, their full measure of reward for their originality and enterprise.

"THE ETERNAL QUESTION" HOW TO MAKE AN ADVERTISEMENT ATTRACTIVE

In this age of advertising, the search for originality and attractiveness is a never-ending one, and brings to light a wonderful amount of creative genius. All of these attempts may be roughly divided into two categories; first, the handsomest or most unique illustrations of the article advertised; second, the picture of a pretty girl. Without having made accurate counts of the relative use of these two methods, it would probably not be far out of the way to state that they are equally divided. In many cases it is possible to combine the two. One of the most successful attempts in this line is shown in the illustration, which, on account of its real artistic merit, has already become familiarly known as the "Lindsay girl." Good taste and art displayed in advertising is a strong argument that the same judgment and high quality are maintained in the article advertised; and the popularity of the Lindsay light rests upon as sure a foundation of intrinsic merit as the popularity of the "Lindsay girl" on good art.

"THE LINDSAY GIRL."

Correspondence

FROM OUR READERS

EDITOR, ILLUMINATING ENGINEER,

Sir:—Under the title: "Is the Carbon Filament Lamp Doomed?" in the May issue of *The Central Station,* 1905, you did me the honor of mentioning my endeavors on the line of an affirmative answer to your question. Under the title: "The Passing of the Carbon Filament Lamp," in the July issue of THE ILLUMINATING ENGINEER, 1906, you were pleased to minimize these, my endeavors, adding, "experimenters" (other), "have been at work accomplishing practical results, and making the rare-metal filament lamp a commercial entity."

Not possibly being ignorant of the fact, that you and your publication had damaged my interests very materially, by giving an unfavorable turn to my pending negotiations, you had the kindness to offer space in your publication to me for a statement of facts, laying bare the true inwardness of the comparative relation between my improved electric incandescent lamp, not as yet in trade, and all other lamps, which have newly been offered in the international market in this line; and I have accepted your kind offer as a full condonement in the premises, on condition that I be really permitted to state the facts of the case.

I have no doubt that my statement will interest all professional engineers, since it relates to that, which I have ventured in my recently published book to call *"The Electric Light of The Twentieth Century,"* and which by the many friends of mine (except one), who have handled my lamps, has been recognized as such, to my great satisfaction, at a time when I am closely approaching the completion of my eightieth year of life, whether it be a "dream" or a fact.

During a period of half a century, when off and on I felt compelled to take part in scientific and technical public controversy, I learned, that the very first requirement in such controversies, consists in defining a precise and rational terminology, and to do this in this case, seems peremptorily indicated by the repeated use you have made in publication, as well as in private communication, of the designation: "Rare Metal Filament Lamp."

Science as well as technology has attached a very distinct meaning to the word "rare metals."

This designation was the result of certain oxides becoming prominent under the name of "rare earths" or "rare oxides." From the latter designation was derived the term "rare metals," and therefore this designation is properly confined to the metals, the oxides of which, by their functional qualities have become and are now prominent as being used as material for Welsbach Mantles.

No better authority for the meaning of the scientific or technical terms: "rare metal," and "rarer-metal-oxides" can be wanted than the Smithsonian Institute has furnished at government expense in the pamphlet: "Vivian B. Lewis, Incandescent Mantles, Washington, D. C., 1901."

And about these terms, the stated authority has the following: "The term, 'rare earths' is one of those anomalies which mar the vaunted precision of science, as although it might be justly applied to the oxides of many metals—these 'rare earths' were generally considered to be: cerium-, lanthanum-, didymium-, yttrium-, erbium-oxides, together with some other even scarcer" though evidently of equivalent functional qualities.

What these functional qualifications are in the matter of using these rare earths or rare-metal-oxides in connec-

tion with the electric incandescent lamp had by me been fully specified in an application of September 11, 1895, later on issued as Patent No. 620,640, as follows:

"First, infusibility at the temperature of the filament under current; second, primary dielectric quality; third, peculiar adaptation to become incandescent at the temperature as stated; fourth, stability in composition, it being more practicable to comply with these four requirements in using and combining more than one kind of these 'rare earths.'"

These "rare earths" were practically introduced into the electric light industry and trade by the "so-called" Nernst Lamp. Compare: The XXth Century Electric Light, Chapter III to VII. And the metals forming them are termed: "Rare Metals."

In co-ordinate classification, but on the basis, "rare metals" aside of and in addition to practical infusibility, of chemical affinity for oxygen, and with the understanding that mainly the metals of the co-ordinate other class are mechanically powderable in their native state (brittle), and of the highest known specific gravity—there is now known in the matter of metals used in filament-making, the other class of metals in distinction from the base-metals to rare-earths, or rare-metals, which other class is specified by the term: "metals of the osmium-ruthenium class," and qualified as: "of high point of fusion, and possessing affinity for oxygen," and of these the ones of most prominent use are osmium and iridium in their natural alloy: iridosmine (Compare Bulletin 193 of Geological Survey).

And though it is fully understood and admitted, that the line of division between the two classes is not a very sharp one, and that some metals combine the characteristics of both classes, and in consequence may be claimed as of both classes—the classification as such is officially and generally accepted. For this no better evidence could be cited than the broad patent for metal filaments, issued to me only yesterday, the 13th of November, 1906, the claims of which read as follows:

Claim.— 1. In an incandescent lamp a permanent metal core covered with a film of other metal of less affinity for oxygen than the metal of the core, substantially as described.

2. A filament for electric incandescent lamps consisting of a plurality of permanent layers of different metals of different degrees of affinity for oxygen, the metals of least affinity for oxygen being upon the outside, substantially as described.

3. A filament for electric incandescent lamps consisting of a plurality of permanent layers of different metals of different degrees of affinity for oxygen, the center thereof being formed by the more infusible oxygenizable metals of which the filament is composed, substantially as described.

4. In a filament for an electric incandescent lamp, a conductive element consisting of metal having affinity for oxygen and high point of fusion coated with metals of less affinity for oxygen, substantially as described.

5. A luminant for an incandescent electric lamp consisting of a conductive filament of layers of different metals, and a coating thereon of rare metals oxids, substantially as described.

6. In a luminant for an incandescent lamp, a filament consisting of a metal core having a high point of fusion and affinity for oxygen, and a plating thereon of metal different from that of the core and having little affinity for oxygen, embedded in rare metals oxids, substantially as described.

7. The combination in luminant for an incandescent electric lamp, of a core of metal having affinity for oxygen and high point of fusion, an insulating coat therefor, and a surrounding light-emitting body, substantially as described.

If I now in a few words state the main facts in the history of my application, on which the patent with these claims was finally issued, I am induced to do so, not only by being cognizant of the fact, that by the nature of all surrounding conditions this history must be, and is, as such of the highest interest to every professional engineer, illuminating engineers surely not expected, but also and mainly because by its, for eleven years delayed, issue exclusively it can be explained, why an invention, ready for

an expectant market, and of the importance of the metallized filament in fact, with the practical proof on hand of its indisputable superiority over any other filament known in the art—did not present itself in the open market, until a plurality of "foreign" experimenters have been at work, and have, as you undertook to state, "accomplished practical results, and made the rare metal (?) filament lamp a commercial entity," as you stated in your July issue, referring undoubtedly to the Siemens Tantalum-Filament Lamp.

When in May, 1904, I had publicly demonstrated the superior qualities of my metallized filament lamps, at Amsterdam, N. Y., I was asked by one of the trustees of the corporation, which had my exclusive license for manufacturing my lamps, the following question: "If we begin now to manufacture on a large scale, these Cazin-Lamps, and some of our employees, who have been taught by you to make these lamps, hire out to other bulb-lamp-factories, who then manufacture and sell them, possibly underselling us, can we stop them and claim damages?" My answer then was, as it could not be any other: "To stop them and demand damages, the issue of patent for my invention, as by me officially disclosed on October 29, 1895, and by order of the examiners-in-chief divided out of my application of that date into a new one on February 2, 1899, is required, but from the date of such issue, which in justice and fairness, cannot be refused to me for any material length of time, infringement can be stopped, unless under our agreement they pay royalty to you, becoming your sub-licensees."

What the inquiring trustees had suspected, soon became a fact, and my licensees were as helpless, in the matter, as if they never had contracted for my license—but this had been well understood by the contracting parties, as the license itself fully demonstates, though my inquirer was apparently unaware of this state of affairs, and since the patent in question had been allowed, once on March 2, 1901, but had been forfeited and renewed, there was no visible or intelligible cause for suspecting, that it would yet take over two years more, or eleven years in all for the patent to be issued. And it is not difficult to understand, why my licensees broke their contract for the time being, and why my first act after issue of the patent has been to offer to them the renewal of the old exclusive license to them.

The history of the case, patented on November 13, 1906, is as follows:

My metallurgical experience made me discard, at an early date, the idea, that carbon will be the exclusively available material for filaments. Not to compromise any further action in the premises, I specified, in my very first application of December 7, 1892, the filament as of "carbonaceous or other semi-conductive material, in the form of a solid line." And in the same application I proceeded one step further and declared, "powdered metal might answer my purpose, the metal in that state being what I call semi-conductive" (p. 3 of Patent, No. 523,460, of July 24, 1894).

This statement is plain evidence of my cognizance of the fact, that metals as such are conductive, and in consequence must be rendered semi-conductive to functionally serve as filaments, and I indicated the means presenting themselves first to my mind for so rendering them. As metallurgist I remembered, that there is a group of metals, distinguished by high temperature of fusion, and that these same metals in their native state are brittle and powderable, and also knowing, that a cohesive solid piece of metal is a better electric conductor than the same metal is, when pulverized, I inserted the cited statement into my first application for patent.

I had not then, in 1892, thought of other instrumentality, such as excessive length of filament, for rendering the same less or semi-conductive, but when in 1897 it occurred to me, that

to carbonize a metal-filament, would reduce its electric conductivity, I made application for protection of the sole, exclusively practical method of doing this, namely electrolytical plating of the carbon-filament in its final form and soon ascertained by experimental work, that under electric current, a mutual inter-impregnation of carbon and metal takes place, leaving a filament of carbonized metal or, what is the same, of metallized carbon, viz.: a metallized filament.

And when later, or in 1899, a third instrumentality for reducing the electric conductivity of a metal-filament, or for rendering it semi-conductive, occurred to me, namely by means of excessive length, I applied for protection by patent of a non-conductive support for a filament of excessive length (July 27, No. 725,283), having previously also protected my utilization of certain metals as filament-material by an application of February 2, 1899.

In this statement relating to my improvements of the glowers or filaments in electric incandescent lamps, I have omitted speaking of two other phases in such improvements, namely:

1. The utilization of rare-earths or of the oxides of so called rare-metals, in these glowers.

2. The use of a chemical-insulation-film between the different concentrically arranged different parts of such glowers.

As to my priority in claiming the utilization of rare-metal-oxides (rare earths) in electric lamps attention is directed to my Patent, No. 620,640, issued on an application of September 11, 1895.

I there amply describe the material to be used by me, as an additional element in the use by my improved filament (page 2, lines 33 to 67) as follows:

I preferably select as the substance for the second sub-element such material as complies with all the different requirements that are conditional to its function —namely, first, infusibility at the temperature of the filament under current; second, dielectric or non-conducting quality in general and when heated to the said temperature; third, peculiar adaption to become incandescent at a temperature as stated, and, fourth, stability in composition when heated in contact with other material or mainly with carbonaceous material. It being more practicable to comply with these four requirements in using and combining more than one kind of solid matter in forming the second subelement in the luminous body, I do not intend to limit myself to the use of only one kind or class of material in constructing the luminous body of my lamp, but I combine and arrange different materials, of which each in its place complies with one or more of the stated requirements whenever this appears as serving my purpose better in the making of the second subelement of the luminous body. It is on this account that I show the luminous body of my lamp as made up of different strata, which surround, inclose, or embed the linear filament or filaments. It is evident, therefore, that relative position only and not the shape of either component part or of the whole luminous body is essential aside of the stated four qualities in the parts or in all of the materials that enter the second subelement.

But it was my fate, as it had been that of Welsbach, in 1885, in his first mantle-application, to mention the oxide of zirconium as representative of rare-earths, a conception, which he had entirely abandoned, when on February 23, 1887, he made his fifth application in the same subject-matter, never referring to zirconia again, except to state, that it be not greatly damaging, if a small percentage of oxide of zirconium be used as substitute for some of the rarer earths.

This mistake of mentioning zirconium as the standard of the class was remedied by me on October 29, 1895 (about forty days later), by my application of that date) on which Patent 621,291 was issued on March 7, 1899), by mentioning other metals which come up to the functional requirements to a far higher degree than zirconium.

The patent states on its first page, in the second paragraph, as follows:

"His application No. 481,231, filed on July 24, 1893, further specifies the embedding solid matter as 'a white, non-transparent solid, which becomes incandescent under the influence of heat,' 'such as Bioxide of Zirconium, and the Oxygen

compounds of *Ebrium and Yttrium,* and other oxides of the specific charcter and suitable for this purpose.'" and (....Claim 19.) "An electric incandescent vacuum lamp, in which the fiament is coated with oxygenated metal of the Zirconium-class, such coating to become luminous and to increase the light-effect of the lamp from a given wattage per candle-power as against the light produced by a filament, without such coating, as and for the purpose set forth."

No earlier mention of the utilization of rare-earths in electric lamps for the increase of their light efficiency is in existence anywhere.

What happened to my oxide-coated carbon, the result of quite different methods of deposition, was by me fully and rationally specified in my last-mentioned application of prior date than the one before the Examiners-in-Chief and under present discussion.

There we find on page 2 of the patent, issued but about a month after the date of the decision under discussion, but applied for four years earlier, the following:

The dimensions that I am dealing with in making up the luminous body or structure are altogether extremely minute, and its component parts or elements or materials can in consequence not be otherwise than of extremely minute dimensions and cannot be of thicknesses that can by common means be measured, though in still so minute thickness they by their chemical and distinct nature perform the function to them assigned—namely, the function of insulation.

When the carbon filament is coated very thinly with oxids of the stated nature and is subjected *in vacuo* to an electric current, simultaneous result of which is the formation of carbon oxid and the deposition on the filament reduced both in volume and in conductivity (increased resistance) of a fine metallic skin or stratum, by means of which a compensating increase of conductivity (loss of resistance) is provided. If the operation is continued uptil the metallic skin is minutely thin as it may be homogeneous, the reaction will cease. With an unreduced coat of oxid left or deposited in a secondary manipulation the luminous body so prepared will consist of the insulated (chemically) filament and the stratum of oxids. If to the first coating of oxids some silicious or aluminous material —namely the formation of silicates or of aluminates, or of both, with the metallic oxids as bases. When in a first operation a metallic skin and an electrically insulating coat of aluminate or silicate has been formed and in a second operation a coat or stocking of oxids is applied, then the luminous body or structure consists of the chemically and electricallly insulated filament and of a stratum of the oxids, as specified.

Here is stated the remedy—"chemical insulation" required to produce a useful filament of carbon with a surface-coating of oxide, and the following claims of the patent give the true inwardness of the case. They read:

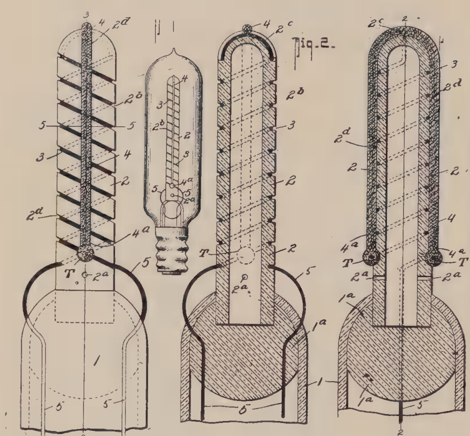
8. In an electric incandescent vacuum-lamp, having suitable contact-providing and supporting-base parts, and an air-exhausted glass bulb, hermetically connected with these base parts, a solid body inside of the said glass bulb and supported by means of inleading wires, or by other supports in connection therewith, of which solid body a linear filament or filaments constitute one part, and of which body concentrical strata of different materials constitute another or major part, and which strata are so selected, that the material in the stratum next to the filament, insulates the filament chemically from the outer strata, and that the material in the outer stratum or strata is made incandescent by the heat emanating from the filament under current, as and for the purpose set forth.

9. An electric incandescent lamp, that is made up of three main parts, namely of a contact-providing supporting part or parts, a glass bulb, inclosing an air-space and the third main part, which is in itself a separate body, supported on the base part, as a body or structure, of which a continuous linear filament or filaments of semiconductive matter, that give off light and heat under current, are an embedded nucleus, which is completely incased by concentrical strata, the inner one of which insulates the filaments chemically from the outer stratum or strata, and the outer stratum of which consists of rare metal oxids, peculiarly adapted to incandesce by the heat given off by the filaments under current, and which are mixed and prepared or selected and prepared to properly perform the function of increasing the light effect of applied energy, as and for the purpose set forth.

Having demonstrated by the patent just issued to me on an eleven-year-old disclosure, my privilege to call the only real metallized filament lamp the Cazin-Lamp, it remains for me to describe what the lamp, as made, is, and what claims it has, to be called THE electric lamp of the XXth Century,

in preference to all others, home-made and foreign.

Not to exceed present demand, and not to abuse your kindness in allowing space for my statement, I shall confine my remarks on quality and achievement to the one kind of Cazin-Lamps hitherto made in large numbers and publicly and authoritatively tested, but I beg leave to shortly mention also the kind, for which patent was issued on May 24, 1904, as well as to insert illustrations of both.



Porcelain fingers for the last-mentioned lamps were made for me in 1894, at the Empire China Works, at 144 Greene street, Brooklyn, N. Y.

The best description of the nature of this lamp is given in the 12th claim of my said Patent, No. 760,849, which reads as follows:

12. In a luminant for electric incandescing lamps, a dielectric heat-conducting supporting part, a heating-coil wound thereon, and adapted to heat said support when under current, a light-producing filament or thread mounted on said support said filament being composed of material which will offer a greater electrical resistance to the current at normal temperature than the heating-coil and which at the elevated temperature produced by said heating-coil, will become of less electrical resistance than said heating-coil to permit the current being shunted through said filament to raise it to incandescence, for the purposes specified.

This lamp is intended to be an improvement on the present complicated so-called Nernst Lamp, and will probably be the third Cazin-Lamp to go before the public.

As 1, I designate the simple Metallized Filament Lamp and as 2, the same with a surface of rare-earths.

The fundamentally progressive step in my attempts to improve the bulb lamp, of existing art, consisted in substituting the carbon and platinum of old in my filaments by metals, the temperature of which is high enough to render them functionally fit for retaining form at the temperature of incandescence. In this my metallurgical knowledge put me on the right road and made me cognizant, as early as 1892, of the fact, that my selection had mainly to be from non-malleable, viz.: powderable (in their pure or native state) metals.

To make filaments of these metals then appeared as the next problem. As a means of rendering them semi-conductive, I utilized them in the form of powder. To form a continuous material line of them, I first embedded them in a solid groove and cover (compare my Patent 523,460, of July 24, 1894), but started on an experimental course for discovering other means for making wire of non-malleable metal, until I discovered the exclusively practical method for doing this, and claimed it officially as my invention on October 12, 1897, in the following words:

"I consider as my invention the arrangement of a carbon filament to form the negative pole in an electrolytic bath in a loop-shape, similar to the shape, in which it is to be used in the lamp, without direct connection with the positive pole, such as used in the common flashing process."

It is worth considering, that the arrangement (method) is claimed, without limiting it to the use of the above-stated metals exclusively, my present practice including in such treatment, aside of the metals of the ruthenium-osmium group, those called "rare metals," because they furnish the Welsbach rare earths, and I

then embed all in rare-earths, if so wanted, forming my lamp No. 2, by oxidizing these on their surface.

While for years all my attempts to produce a metal filament, that be of acceptable qualities for substituting the carbon filament, had met with nothing but failures, as far as commercial acceptability was concerned, the bringing in of the products of electrolytic deposition, and their feasibility not only, but by the very specific qualities of these deposits *solved all difficulties in the premises at once.*

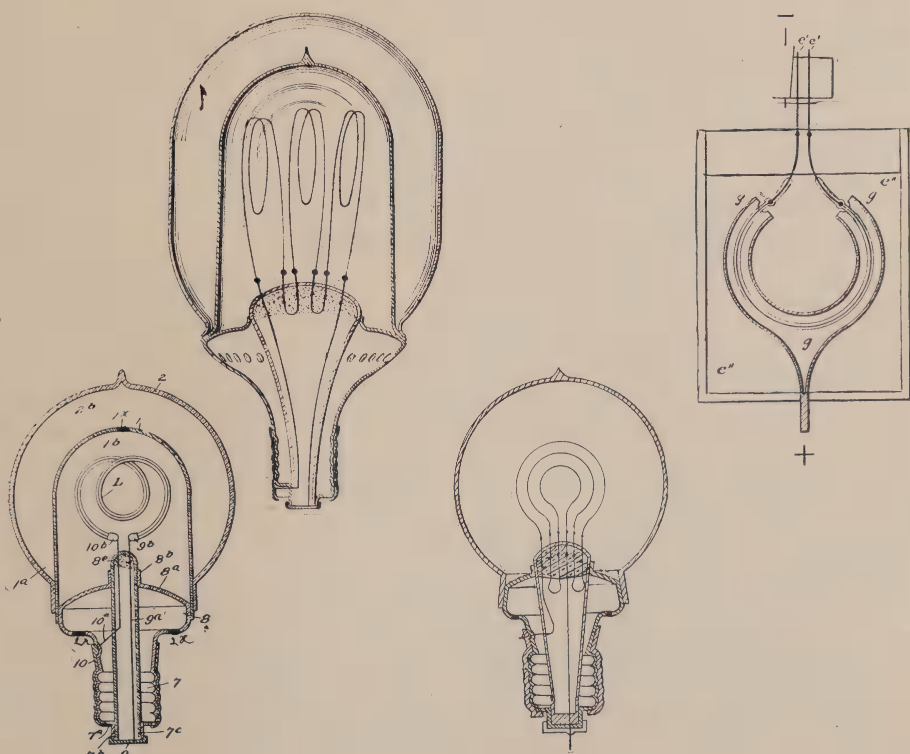
I found no material difficulties in depositing thus any single metal of those that I had selected, but was also successful in depositing alloys in proportionate composition, such as by me intended.

Since I introduced and published in many ways, though as yet not by going into the open market, my improved metal-filament lamp, many attempts have been made, and made amongst others by Welsbach and Siemens, to attain my results in other ways, while nobody to me known as yet has contested my inventor's privilege in the lamp metallized by electrolytic deposition and subsequent adequate treatment.

I insert the drawing, which accompanied my above-cited disclosure of October 12, 1897, showing how I had overcome, previous to that date, the first difficulty met, when I interchanged in a common carbon lamp my filament for the carbon, in the usual terminals. The terminals evolved excessive heat and melted off—but when I had coated the terminals with metal, the same as the carbon, by immersing them into the electrolyte—increasing their conductivity—then no longer would overheating of terminals occur.

F. M. F. Cazin.

Hoboken, N. J.



Illuminating Engineering Society

ABSTRACTS AND DISCUSSION OF PAPERS READ BEFORE THE NOVEMBER MEETING OF THE NEW YORK SECTION

LOCATION OF LAMPS AND ILLUMINATING EFFICIENCY

By Preston S. Millar, *Member.*

Every problem to which the illuminating engineer directs his attention requires individual treatment. Its successful solution demands of him ingenuity, good judgment and artistic sense no less than a knowledge of engineering principles and familiarity with the values and characteristics of artificial illuminants and accessories. In view of the importance of each of these, it is felt that no apology need be made in asking your attention to one particular feature of the work to the practical exclusion of all other considerations, however impossible it may be to ignore the latter in practice.

It is the purpose of this paper to consider the relative efficiencies of four different methods of indoor illumination which are in common use today, using as a basis precise measurements of the intensity of illumination produced by incandescent electric lamps used with various fixtures variously placed.

Lack of opportunity to carry out a series of tests for incorporation in this paper has made necessary the adaptation to our purpose of tests made at the Electrical Testing Laboratories with other objects in view.

The conditions are not in every case just what one might wish, but it is hoped that the results may be of practical value.

THE TEST ROOM.

The experiments were made in a rectangular room, approximately 16 feet long by 11 feet wide and 12½ feet high. The ceiling and walls are finished in a light-buff color, the ceiling construction being steel girder and brick arch. The floor is painted light red. There are three windows, one of transparent glass 6 feet 11 inches high and 3 feet wide, one of translucent glass 5 feet 6 inches high by 2 feet 6 inches wide, and one of translucent glass 5 feet 6 inches high by 2 feet 3 inches wide. Fig. 1 shows the plan of the room and the location of test stations at which measurements of illumination on a horizontal plane 3 feet above the floor were made. As no other measurements of illumination were made, this study will be confined to the particular plane referred to without any reference to the effect upon the other portions of the room.

LIGHTING INSTALLATION.

In this room lamps have been installed for test purposes at various times as follows:

Ceiling Installation.—Twelve 16-candle-power lamps in the ceiling, tip downward, one lamp located directly over each of the twelve illumination test stations, as shown in Fig. 1.

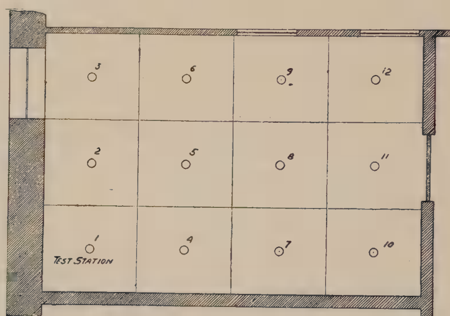


FIG. 1.

Drop-Cord Installation.—Six 16-candle-power lamps on drop cords, suspended at a height of 9 feet above the floor, directly over the illumination test stations Nos. 1, 3, 5, 7, 9 and 11, as in Fig. 1. The peculiar arrangement of the lamps in this test was the result of considerations which are of no interest in this connection.

Chandelier Installation.—Four 16-candle-power lamps at a height of 7 feet 1 inch above the floor, placed in a chandelier suspended in the center of the room. The arms of this chandelier were approximately 1 foot 6 inches long. The lamp axes formed angles of approximately 45 degrees with the vertical. The chandelier arms were diagonal with the room.

Wall-Bracket Installation.—Four 32-candle-power lamps placed upright in wall brackets 7 feet above the floor, located symmetrically one on each of the four walls.

All of the above lamps were of the oval filament type, and were operated at the voltage at which they gave their rated candle-powers. They were used alone and with reflectors and globes as stated hereafter.

PHOTOMETER.

This is a Weber photometer in which certain important changes have been made in order to obviate considerable errors. The illumination is received upon the circular translucent test plate which may be seen in the upper surface of the box upon the table top. This apparatus bears the following meritorious features which are usually lacking in instruments with which intensity of illumination is measured.

Instrument parts, and of necessity, the observer, are below the test plane; no objective interference with light coming from any direction.

Test plane which does not vary sufficiently from Lambert's law of the cosine to introduce material errors in such tests as those recorded herein.

Accuracy of measurements irrespective of direction from which light is incident upon test plate.

EXPRESSIONS OF ILLUMINATING EFFICIENCY.

All efficiency values are based upon the numerical averages of the figures representing intensity of illumination throughout the entire plane investigated, because the various test stations are located at the centers of equal areas symmetrically disposed. In considering these, it should be remembered that no comparisons can be drawn between the reflectors and globes used, since the installations were radically different.

The three large factors to be considered in determining the total efficiency of electric lighting are: The efficiency with which the energy is generated and transmitted, the efficiency with which the light is produced, and the efficiency with which the light is utilized. With the last two the illuminating engineer is intimately concerned. As respects a particular lighting installation, the efficiency of the lamps as illuminators may be expressed in "lux per watt." Separate and distinct from this is the term "lux per lumen" which expresses the efficiency of the illumination irrespective of the efficiency of the lamps. Both are of use, but have not necessarily any definite mutual relation. The "lux per lumen," being the ratio of the illumination to the flux of light, depend largely upon the location of the lamps, the nature of their distribution of luminous intensity and the nature of the surroundings. The "lux per watt" being the ratio between the illumination and the energy absorbed, depend upon all the conditions which determine the "lux per lumen," but in addition are a function of the efficiency of the lamps. The other expressions such as "lux per candle-power" and "lux per square foot of floor space" are frequently used in practice.

EFFICIENCY OF ILLUMINATION.

One of the important features of the data obtained by the test is the increased efficiency of illumination due to the use of reflectors in the drop-cord installation, where a gain of 46 per cent. in intensity of illumination is made. The reflectors used in the chandelier installation are not so effective, the opal reflectors increasing the illumination 17 per cent. and the prismatic reflectors 25 per cent. The smaller increase in illumination here observed is not chargeable to the nature of the reflectors, but is due rather to the fact that they are used upon the chandelier in the haphazard fashion common to such practice, where the use of reflectors is dictated by a desire to make the chandelier look complete rather than to improve the illumination.

The Holophane globes used in the wall-bracket installation were of the combination type with reflecting prisms on the side nearest the wall and diffusing ribbings with directing prisms on the other side. Through a misunderstanding these globes, which are designed to direct the major portion of the light toward a zone slightly below the horizontal, were submitted for test when globes calculated to provide the best illumination at an angle of 45 degrees were prescribed. Failure to produce any material improvement in illumination with these

Installation.	Position of Lamps.	Height Above Plane Investig.	Eff. of Ill. in Terms of Ceiling Lamps.
Ceiling	Pendant	9 ft. 2 in.	100%
Wall bracket	Upright	4 ft.	115%
Drop cord	Pendant	6 ft.	136%
Chandelier	Axis 45° to vertical	4 ft. 1 in.	194%

TABLE I.

globes should, therefore, be attributed to the fact that they directed a great portion of the light toward the opposite wall rather than toward the plane to be illuminated.

In considering the effect of the position of the lamps upon the efficiency of the illumination, only the bare lamp installations have been taken into account. The efficiency secured from each installation is as in Table I.

Further discussion of these differences in efficiency will be undertaken later.

UNIFORMITY.

Considered from the standpoint of uniformity of lighting, a fair state of affairs will be found, except with the lighting by the chandelier installation. Here we find characteristic lack of uniformity which is somewhat increased by the use of both opal and prismatic reflectors.

REFLECTION FROM WALLS AND CEILING.

We will now consider the part which the walls and ceiling play in the illumination of this horizontal plane. It will be remembered that these are finished in a light buff color so that their coefficient of reflection will be neither extremely low nor extremely high. It will be remembered also that a small room is under consideration and that therefore the reflected light from the walls is of much importance as affecting the average intensity of illumination throughout the entire plane in which the measurements have been made.

For the purpose in view the installations of lamps without reflectors will be considered. When reflectors are used the problem is much complicated and conclusions are more likely to be erroneous.

The horizontal illumination produced by each lamp in a given installation at the point where each of the twelve test stations is located has been carefully computed, taking into consideration the candle-power which each lamp delivers in that particular direction, the distance of the test station from the lamp, and the angle at which the rays of light are incident upon the horizontal plane. The sum of these values at a particular test station is taken as the intensity of illumination produced by the lamps directly. The difference between the total illumination and the illumination produced by the lamps directly is due to light reflected from the walls and ceilings. Table II. sets forth the data so obtained and shows the very great influence which the location of the lamps in this installation has upon the illuminating efficiency. With all other conditions constant, different locations of the lamps vary the reinforcing effect of the ceiling and walls throughout a range of from 45 to 166 per cent.

It will be apparent at once that in a room such as that described the factor K is a variable, the determination of which presents serious difficulties. The extent of this variation will be appreciated when it is seen that with the factor 0.31 which obtains with the wall-bracket installation the effect of the reflected light from ceiling and walls is to increase the illumination by 45 per cent, while with the factor of 0.62 which obtains with the ceiling installation, the effect of the ceiling and walls is to increase the illumination 166 per cent. If then, an illuminating engineer should assume the factor of 0.62 for this room and should install the lamps in such positions that the factor of 0.31 would apply, the effect would be nearly as bad as though the building engineer had installed 8-candle-power lamps when 16-candle-power lamps were prescribed. Yet it is not beyond the bounds of probability that the effect of the ceiling and walls should be so badly misjudged.

REFLECTING EFFICIENCY OF THE CEILING AND WALLS.

We shall base conclusions as to the reflecting efficiency of walls and ceiling upon data obtained from the ceiling, drop-cord

AVERAGE INTENSITY OF ILLUMINATION AT TWELVE TEST STATIONS.

Installation.	Direct Illumination from Lamps (Computed).	Total Illumination (Measured).	Per Cent Increase Due to Diffuse Reflection.	K.
Ceiling..........	8.5 Lux.	22.5 Lux.	166%	0.62
Drop cords.......	7.0	14.8	113%	0.53
Chandelier.......	8.9	14.0	69%	0.36
Wall brackets....	11.6	16.7	45%	0.31

Note—K is factor for wall reflections which appear in the formula $E=e\left(\frac{1}{1-K}\right)$

TABLE II.

and wall-bracket installations with bare lamps. The total flux of light from bare lamps used in each installation has been analyzed to determine the total lumens which provide the direct lighting on the plane under consideration, and the total lumens which fall upon the ceiling and walls above the plane. This yields the interesting information that only from 5 to 10 per cent of the total light emanating from the lamps goes toward the direct illumination of the plane. In the case of the drop-cord installation, 8 per cent of the light is effective in this manner, while 92 per cent. is directed toward the ceiling and walls above the plane. After more or less multiple diffuse reflection the portion of the latter, which is not absorbed, finally assists in the illumination of the plane. This 92 per cent., if directed at the plane, would have increased its illumination by about 1150 per cent. The portion of it which finally reaches the plane increases the illumination by about 113 per cent. Each lumen which might have produced 0.09 lux now produces 0.008 lux. Ninety per cent of the

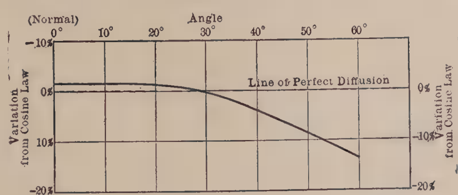


FIG. 2.

light which falls upon the ceiling and walls, or 83 per cent of the total light generation is absorbed by the ceiling and walls.

For the purpose of this discussion, the efficiency of the direct lighting on the plane investigated will be considered as 100 per cent. The net efficiency of the ceiling and walls being considered the ratio between the lumens which they deliver upon the plane (as judged by the illumination which they produce) and the total lumens directed toward them from the lamps is, in the case of the drop-cord installation, 9.7 per cent. The foregoing information with similar data for the ceiling and wall-bracket installations appears in Table III.

Table III shows that the wall-bracket installation secures a larger proportion of direct lighting than do the other installations, but it shows, on the other hand, that the light which is directed toward the ceiling and walls from the wall-bracket installation is more largely absorbed before reaching the plane to be illuminated than the light falling upon the ceiling and walls from the other installations. This is probably due to the fact that the general trend of the bulk of the reflected light from these lamps is along the walls horizontally, while with the ceiling and drop-cord installations the general trend of such reflected light is downward toward the plane to be illuminated.

GENERAL CONCLUSIONS.

From the foregoing it appears that in the room described with different locations of bare lamps:

1. The relative illumination in terms of that produced by the ceiling illumination varies from 115 to 194 per cent.

2. The increased illumination on the plane investigated, due to diffuse reflection from ceiling and walls varies from 45 to 166 per cent.

3. The factor K varies from 0.31 to 0.62.

4. The net reflecting efficiency of the ceiling and walls varies from 4 to 10 per cent.

	Installation. Ceiling.	Drop Cords.	Wall Bracket.
Total lumens	2003.	1001.	1335.
Lumens falling directly on plane	94.	80.	119.
Per cent	4.7	8.	8.9
Illumination by direct light			
Lux	8.5	7.0	11.6
Lux per lumen	0.090	0.088	0.097
Illumination by reflected light			
Lux	14.0	7.8	5.1
Lux per lumen	0.0073	0.0084	0.0042
"Efficiency" of walls	8.1%	9.7%	4.3%

TABLE III.

INTERPRETATION OF MEASUREMENTS OF ILLUMINATING EFFICIENCY.

In this connection it is important to note that the determination of intensity of illumination is attended by many practical difficulties which do not enter into ordinary photometry, and is therefore more liable to error. Results of illumination tests are not worthy of consideration unless accompanied by a detailed description of the installations under test, a statement of the conditions of the installation and a statement of the conditions affecting the measurement.

Reliable measurements of illumination are of great value as leading to a proper analysis of the results obtained under given conditions. However, on account of the large influence which local conditions and arrangements exercise, it is absolutely unsafe and inadmissable to attempt from data obtained in illumination tests to draw conclusions as to the relative or absolute values and efficiencies of the light sources even though the accuracy of the tests be beyond question.

It would seem unnecessary to lay emphasis upon so obvious a point, were it not for the fact that reputable writers in our technical press have deduced from measurements of illumination, under a particular set of conditions, values purporting to show the relative efficiencies of the illuminants tested.

FIXTURE DESIGN AND LOCATION

By Major E. I. Zalinski, U. S. A.,
Member.

The design of fixtures for electroliers is left, in a large measure, to manufacturers, most of whom appear to give but little thought to securing efficiency of illumination. Economy as to the construction of the fixtures, or of the cost of the resulting illumination, appears to be entirely beneath them, except in cases of active competition when they may attempt to lower the cost of fixtures. If the resulting illumination happens to be sufficient, it is ordinarily secured by the most wasteful expenditure of current. But the fixture makers do not pay these continuing bills.

It is the especial role of the illuminating engineer to secure proper lighting, avoiding uncomfortable physiological conditions at a minimum outlay for current or gas. It is this consideration that renders advisable to give first consideration to fixture design and the location of fixtures.

In times past it was the custom to acknowledge frankly the necessities for suitable lighting, by the use of chandeliers more or less elaborate, suspended some distance below the ceilings, and by numerous brackets carrying one or more lamps attached to the walls, central posts and pillars. No attempt was made to conceal them. In this way the lights ordinarily furnished a moderate degree of illumination somewhat commensurate with the expenditure of gas or electric current, as the lights were thus brought near to the planes where required.

But in these latter days the tendency has been either towards very wasteful indirect lighting, or to placing the electric lamps up close to the ceiling, or even above the same, at needlessly great distances from the plane where the illumination is required. Often, not being content with this unfavorable lo-

cation, the lamps are covered with the large glass beads, well fitted to aid in destroying the little light left available.

An examination into the laws governing the intensity and distribution of light here appears desirable. It is a fundamental law that the intensity at any distance from the source of light is inversely as the square of the distance. This assumes a radiant point of light as being the source. In other words, the intensity of illumination at various distances from the source is thus computed in the attempt to secure definite illumination. The lighting arrangements are then made to conform to this, some allowance being made for the color tone of the walls and ceilings. A modified formula will have to be used where the source of light is not a point, as for example, in the cases of the Cooper-Hewitt and Moore tubular or similar lights, which may be said to have more than one dimension.

There is some question as to the strict applicability of the law of inverse squares to the cases where reflectors are used, even with single incandescent lamps. But unless these reflectors are in whole or part of the parabolic type, securing a reflection approximately parallel to the axis, the law of inverse squares must still apply, approximately at least.

In cases where the reflectors are partially parabolic, the law of inverse squares will apply to the angles outside of the axial angle, the rays of light being parallel at the latter.

Generalizing, three cases may be assumed:

1. Reflectors parabolic throughout, where the law of inverse squares will not apply at all.

2. Reflectors partially parabolic, where the law will apply to the extraneous angles, but does not apply to the axial and immediately adjoining angles.

3. Ordinary conical and dome-shaped reflectors where the law of inverse squares practically applies throughout the field, but must be based on actual photometric measurements at different portions of the field.

We may now assume that the reflectors used are not in part or wholly parabolic. Taking a concrete case, computations made on the basis of the law of inverse squares would indicate as follows:

The height of ceiling is taken at 16 feet. The plane to be illuminated is taken at 3 feet above the floor, or 13 feet below the ceiling.

Assuming an intensity of 16-candle-power at 1 foot distance, we have available at

4 feet — 1.0-foot candle
5 feet — 0.64-foot candle
6 feet — 0.44-foot candle
7 feet — 0.32-foot candle
8 feet — 0.25-foot candle
10 feet — 0.16-foot candle
13 feet — 0.09-foot candle

The illumination demanded for ordinary good print reading is 1-foot candle; for newspaper print 2-foot candles; for the postal service 4-foot candles, and for drafting 10-foot candles.

Assuming the 2-foot candle at the plane 3 feet above the floor as the basis, if the light were placed at the ceiling, 338 candle-power would be required to secure the requisite illumination at the 3-foot plane.

At 4 feet below the ceiling, this would be reduced to 162 candle-power, or a little less than one-half.

At 6 feet below the ceiling it would be reduced to 98 candle-power, or less than one-third.

At 8 feet below the ceiling it would be reduced to 50 candle-power, or less than one-seventh. It is thus seen how very wasteful much of the usual lighting fixture arrangements are in the available illumination.

It is obviously desirable from consideration of economy and efficiency of illumination to place the lights as low down and as near the plane to be illuminated as possible, the gain thus secured increasing very rapidly. But various other considerations serve to limit and modify the extent of the lowering which is practically possible or desirable.

The high intrinsic brilliancy of the clear prismatic glass reflectors, in the axial angles, renders it necessary for comfort to raise the lamps high, to avoid the uncomfortable glare incidental thereto. The higher candle-power obtained at the axial angles renders this feasible, but this results in a reduced illumination at the extraneous angles.

Diffusing reflectors having a lesser intrinsic brilliancy may be placed lower and nearer the eyes without injury to the latter.

The law of inverse squares has application not alone in the height of placement of fixtures, but has also direct application in the matter of most advantageous subdivision, lateral distribution and number.

Considerable variation in the maximum and minimum of the illumination becomes, for physiological reasons, most disadvantageous. The retina of the eye quickly adapts itself to the brightest lights, reducing its opening accordingly. Where adjacent zones are of a comparatively lower intensity, they thus are made to appear relatively darker, and the illumination consequently becomes more ineffective in securing distinct vision of details.

For these reasons a more uniform illumination is desirable, with an avoidance of high intensities and a lessened variation between the maximum and minimum. By the use of the smaller units the variation in intensity is minimized. It is, therefore, more advisable to have a larger number of smaller units, well distributed, than a smaller number of the larger units. The small units also secure an avoidance of deep shadows which are detrimental to clear vision and a due appreciation of the proportion and relation of objects in the field of vision.

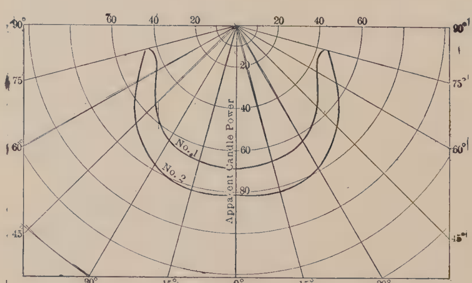


FIG. I.

The lamps must be well above the head and eyes. A distance of 8 feet from the floor is assumed as a minimum height, giving ample head room and being above the direct vision of the eyes.

Fig. 1 gives the distribution curves of two kinds of reflectors. Curve 1 is of a plain prismed glass reflector, and curve 2 that of the same reflector with a diffusing backing. It is seen that the latter in this case gives superior results, both in the axial and the extraneous angles, to those from the plain prismed glass. The diffusing reflector is on a parity with the plain prismatic when at about 40 degrees on either side of the horizontal. This, of course, bespeaks for the former a superior distribution and more efficient illumination.

A good general illumination is of the first consideration, but may be of a very moderate intensity according to the general conditions. But besides this, there should be provided locally, illumination of higher intensity to provide for special conditions.

The illuminating engineer not infrequently meets with difficulties in making his designs in accordance with the requirements for proper illumination, because of the fact that not infrequently the wiring has been done independently. It is obviously desirable to have the wiring done under plans made by the illuminating engineer, who can thus design the arrangements untrammeled by unsuitable wiring.

FIXTURE LOCATION IN RESIDENCE LIGHTING

By F. N. Olcott, *Member.*

In taking up the subject of residence illumination and location of residence fixtures, we enter into a field that has no set rules, owing to different tastes of owners and their varied ideas of illumination. There is a great similarity among average residences. They usually comprise a vestibule, hall, parlor, dining-room, library, bedrooms and other less important rooms. Each of these rooms has accepted types of fixtures, which have been developed in meeting the general requirements and the urgencies of mechanical construction, but in details of design they are unlimited. In the use of candles, oil and gas the fixtures had to be constructed so as to eliminate as far as possible the chance of burning or damag-

ing the ceilings and walls, which caused the center fixture to be hung as far as possible from the ceiling and the brackets to be extended considerably from the wall. The chandeliers and brackets gradually increased in size until they became the most prominent feature in the room and dwarfed its size. These facts were lamented, but had to be accepted with the means of illumination then available. The question of illumination was left entirely to the owner, who could use as many burners on each fixture as he was willing to pay for and who usually selected the design. Frequently a purchaser would select one design and use it throughout his house, simply varying the number of lights. An exception to this was the hall, where a lantern was invariably used. Others made an exception of parlor, library and dining-room. If the ordinary burner furnished with the fixture did not supply him with enough light he experimented with the newest burner that claimed the greatest amount of candle-power, with only one thing in mind—to get as much light from one source as possible. The designer was not hampered as to the number of lights he put on a fixture, and could use any number.

The introduction of electricity has changed the conditions previously existing. The danger of fire and smoke is practically eliminated at the light and the designer is given an opportunity to create a lighter and more graceful fixture, gradually doing away with the old type chandelier and developing the present ceiling electrolier. This gives a far more pleasant illumination, as the source is above the normal line of vision and the eye is not offended by the glare of the lamps. It also increases the apparent size of the room and sets off the decorations to a better advantage. When the hanging fixture is necessary for use or decorative purpose, the lights can be better screened and the fixture kept in proportion to the room. This is undoubtedly one of the reasons of the popularity of electric lighting over gas, the gas simply being used for emergency purposes and preferably on the side-brackets and in the service portion of the house.

To properly light a residence with electricity, the first and most important principle is to have the wiring properly installed with a full allowance of lights for each outlet, and the outlets carefully located for effective illumination of the entire room and with the light so controlled by switches that the owner can conveniently use as many or as few lights as is desired. The proper allotment of lights at the time of installation is consequently of the utmost importance.

The real problem in residence illumination is to create an efficient illumination without a glare at the source. This cannot be done if the lighting of the room depends upon a few lights of large candle-power. It therefore necessitates the use of a number of units of small candle-power, and this consideration should be given careful thought by the architect and illuminating engineer when laying out the wiring. It is very difficult to make any change after the residence has been completed, and poorly designed wiring layout may prevent the fixture designer from securing a satisfactory illumination, as the fixtures have to be supplied with lights within the wiring specifications in order to obtain the underwriters' certificate. The owner is then forced to put up with an insufficient amount of light or to exceed the specified capacity of the wiring by using a larger candle-power lamp. This procedure, aside from the risk from violating the rules, will not give a pleasing effect.

Insufficient and misplaced outlets are met with very often and are one of the greatest hindrances to the fixture man in the execution of his part of the work; at the present time the fixtures are the last thing considered. When the question of fixtures is taken up, the house is practically completed and to make any changes would mean the taking up of floors and often the cutting of walls, to which the owner will rarely agree. I feel that the members of this society can do much to overcome this condition, the main reason for which is the keeping down of the cost; but I feel confident that in nine cases out of ten, if the necessity for more wiring and switches is properly explained to the owner, he will not hesitate at the expense. I cannot recall an instance when he has not blamed the architect or electrician for any shortcomings in this line, and a little insistence at the right time

would have saved them censure and given the owner the proper lighting and switching conveniences he is entitled to, without the extra cost and annoyance in making changes.

A residence can never be illuminated on the principle solely of so many candle-power to a square foot, as there will always be a necessary waste of light in connection with decoration, which depends on the taste of the owner, and this factor should be carefully considered at the time of installation and the owner impressed with its importance.

The present tendency is toward wall brackets. These should be distributed around the room so as to overcome all shadows, permit of a shaded light, and yet give enough illumination to supplement the ceiling fixture in complete illumination. The public is getting more fastidious in regard to the interior of their homes and more particular as to the carrying out of their own ideas, yet they are usually simply guided by the architect, decorator or fixture man. This condition prevents any generalization as to residence fixtures, but the main object should be to have the fixture part of the general scheme of the decoration of the room, and each room should receive its share of attention.

The fixture with the light at an angle has practically been done away with in the better residences on account of the unpleasant effect on the eye, it having been found that a more satisfactory effect is produced with the lights either up or down on both the brackets and ceiling fixtures, as this permits of shading the lamp from the eye by means of decorative shade. Installing a lamp upward on the bracket has proven to be the most practical method for general use, for then with the ordinary open-glass shade the lamp is screened from the eye and its light reflected on the ceiling, which adds to the general illumination. In the case of the ceiling fixture, the lamps can be enclosed in a decorative manner when desired.

DISCUSSION.

Before beginning the regular order of business President Marles called upon Mr. Forestall, the newly elected chairman of the New York Section of the Society to make a few remarks. Mr. Forestall spoke briefly as follows:

The tendency throughout the country in the last few years seems to have been to bring the gas and electric companies together separately, without bringing the gas and electric men together in any society. As I read the signs of the organization of this society, it is going to be a place for gas and electric men to get together and tell each other what each can do. It is also going to be a good thing for the public, it seems to me, because, as I understand it, our object is to show the public how they can get the most light for their money. I have always held that the gas company, or the electric light company, that taught the consumer to get twice the amount of light that he was getting before from the same amount of gas or electric current, was really cutting the price of the gas or the current that he had to furnish, and that when you come to consider the cost of service to a community the important item of that cost is whether the company—or the municipality, if it is a municipal plant—is teaching their consumers how to get the most for their money. In the course of my investigation I have found many companies that do that, but I have never found a municipality that did. That is one of the strong points against municipal ownership in considering the cost to the consumer. Now I think that this society has a great field before it in reducing the cost to the consumer without reducing the income to the company, and I hope we will be able to work out that future.

Major Zalinski said that as he had some question of his ability as an extemporaneous speaker he had jotted down a few remarks on Mr. Millar's paper, which he read, as follows:

Mr. Millar has given us data which will aid illuminating engineers in determining definitely what is requisite for any desired illumination. Coming from one who has devoted so much attention to this subject, the paper is more than ordinarily instructive. The data given is hardly obtainable elsewhere. The investigation in so concrete and thorough a manner of the distribution of the illumination is unique and must be successful.

We are fortunate in having available the very complete installation of the electrical testing laboratories and its competent staff. I can testify from nearly three years' experience as to their conscientious thoroughness. During this time I have had occasion to place before them a variety of questions on illumination and illuminating appliances. The results so obtained have determined the trend from time to time of any further investigations. They have enabled me to decide as to the line of development likely

to secure the better results. If I have any adverse comment to make it is that I thought them to "lean backward" in the direction of over-conscientiousness. But this trait presented assurance that my individual results and counsels were also kept inviolable.

I am compelled to call attention to one particular portion of the paper broaching on my own investigations. This is embodied in the latter part of Table 2—page 7.

I have already had measurements made in my own behalf with clear prismed glass reflectors and with diffusing (coated) reflectors of similar dimensions and angles of opening. But I saw for the first time, in Mr. Millar's paper, the comparative data obtained with opal and other reflectors.

I have reason to be satisfied with the more uniform distribution, and the much lesser variation as between maximum and minimum illumination securable with the diffusing reflectors. The investigation of Table 2 will make the extent of this obvious.

Some of the data given is not in some ways quite comparable with that obtained for me. In the investigations made in my behalf, variations between maximum and minimum were as follows:

Clear prismed glass reflectors, 122.1%.
Diffusing (coated) reflectors, 73.6%.

Or a change of 48.5%.
Or a gain of 65%.

The results as given by Mr. Millar, both for the opal and clear prismatic reflectors, far exceed this relative change. As previously indicated, this greater change may be ascribable to the particular conditions of these latter investigations. But the results of these are of value.

Illuminating engineers are under great obligations to Mr. Millar in having placed before us this valuable data and paper.

Mr. J. H. Halberg called attention to an important point in the address of the local chairman, namely, the co-operation between the society and the electric lighting and the gas companies. It is of course necessary for us (illuminating engineers) in the first place to secure for our clients the lowest possible cost of electric lighting; whether we have to consider the effect of the saving on the earnings of the lighting company, is another point. It is of course well to work together; at the same time where we secure our fee we are supposed to exhibit our energy and produce results. The question of reducing the cost of lighting to the consumer is a very important one; by giving the consumer a lower cost for his lighting we induce him to use more light and at the same time secure better results.

Mr. Olcott's suggestion of using the lamps on chandeliers in a vertical position, whether turned up or down, he considered a very important one, because of the introduction of the higher efficiency in incandescent lighting-units, which will require the placing of the lamps further down. From his observations in the last couple of years he had been able to reduce the cost of electric lighting in some instances as much as 50 per cent. without an expenditure of perhaps more than 10 or 20 per cent. of the saving effected.

Mr. E. Y. Porter took up the question of the illumination of the ceilings and walls. It seemed to him from the practical point of view—and the tests brought out by Mr. Millar simply seemed to bear it out scientifically—that while the increase in the illumination on a horizontal plane due to reflection from the walls and ceilings is very great, that the improvement in general effect is perhaps even greater. In a great many cases the illumination is not only for the purpose of lighting a particular horizontal plane, but for lighting the room as a whole, the walls and ceilings, as well as the floor and desk, or whatever may be there. Both from the artistic and utilitarian standpoints, as well as to prevent great contrasts of light and darkness and their effect upon the eye, it therefore seems to him that the use of shades, or arrangements of lamps, of any form of lighting, which throws all the light downward is not necessarily the best, nor the most practical, nor the most artistic.

With regard to the law of inverse squares and parabolic reflection, he suggested that the size of the parabolic reflector would have a great effect upon the law, when used with incandescent lamps or light sources which are not strictly a point, because the variation from the point source would be relatively much less in the case of a large parabola than in the case of a smaller, so that even in the case of an incandescent lamp, if it were a small reflector it might throw the light in a number of ways, whereas if the reflector were large it might follow the inverse squares law.

He believed that uniformity has a great effect upon the actual illumination required for various lines of work, and referred particularly to the figure of 10-foot candles given for drafting purposes on page 3. He had had occasion to do some drafting where the illumination was nowhere near 10-foot candles, but by having it very uniform, without any chance for direct reflection from the surface of the paper, and having all the space about uniformly lighted, the ease of working was as good as—much better, in fact, than where a much more intense illumination was afforded by a single, or one or two intense sources of light.

Dr. C. H. Sharp took up the reflector question which has just been mentioned. He thought that while, in one way, the classification which Major Zalinski had made of reflectors was of value, yet we should not

lose sight of the fact that the inverse squares law applies to all reflectors, parabolic or otherwise, which can be practically used, provided only that you go far enough away from your reflector to make your measurements. Within certain regions near the reflector the inverse squares law does not apply; if you go far enough away, it does. In the case of the searchlight we have the parabolic mirror, and at the focus of the mirror is the end of the positive carbon of the arc. The source of light is the crater of the arc. Now this crater is pretty small compared with the area of the whole reflector, but the actual practice is to measure searchlights in accordance with the inverse squares law, only we must go a mile or two away to have the inverse squares law work. That is to say the virtual luminous source is not in that case where the arc is, but at a point back of the reflector. In other words, we must go far enough away so that the whole surface of the mirror becomes to all intents and purposes a point of light; then our inverse squares law holds. Now, in actual cases of measuring reflectors we have to use them at distances which are comparatively short, and within these distances the inverse squares law would probably hold in very few cases.

We can, however, make measurements which are useful and valid for such cases by measuring the intensity at a certain distance from the reflector. This intensity is not the true candle-power, because the inverse squares law does not hold, but is an apparent candle-power; so that results of this sort should be expressed, not in actual candle-power, but in apparent candle-power at a certain distance from the reflector, and we must always give the distance. Then we are free from complications of this sort. To be sure, we cannot use data of that sort in drafting correctly another candle-power at another distance. In order to do that we must know the conditions and circumstances. But in moderate distances, if we don't go too far, the inverse squares law holds with a fair degree of approximation, and can be used for the ordinary purposes of illumination.

A distinction was made between reflectors that are parabolic throughout and reflectors that are partial reflectors, etc. This is not very useful from the standpoint of the illuminating engineer, because, whatever, the shape of the reflector, the inverse squares law is not going to hold, if you are too near to it; and, as has been pointed out by the author of the paper, if we use an incandescent lamp with a reflector there is only one point that is going to be focused.

Mr. G. V. Williams wished to ask Dr. Sharp whether he thought that there should be some change of design of incandescent lamp filaments for the purpose of meeting the needs of the engineer. The development of the filament has been quite interesting. The general type is the oval loop, but there have been some experiments made in other directions, particularly in getting a uniform distribution of light. Some filaments have the light very much localized as in the case of the two- or three-coiled; but the new lamps, such as the Tungsten, will have the filament much longer, and the distribution of light will be almost altogether in a horizontal plane; the tip candle-power will be almost nothing. Such a form is necessitated by the character of the filament, and the conditions under which we have to work in anchoring it to get the necessary rigidity. It may not be possible in that type of filament to get a concentrated light, and before these lamps occupy the field exclusively, it is desirable to know whether there is any necessity of change from the form of the carbon filament.

Dr. Sharp replied that he did not consider that it was of sufficient importance to justify a change in incandescent lamp filaments. He wished to point out that if an incandescent lamp filament is so designed that it gives a relatively large proportion of light down, it sends also a relatively large proportion of light up into the base, where it is pretty hard to catch by any method at present known.

Mr. Williams thought that if the bases are attached with plaster of Paris the coefficient of reflection would be rather large.

Mr. E. L. Elliott stated that while Mr. Millar's paper as read was certainly most interesting and valuable, he had reason to believe that the writer had not shown his entire hand, but had some data up his sleeve that would prove as interesting as any that he gave, and certainly of equal value, and that he did not think it would be any breach of confidence if that information were given.

The President called upon Mr. Millar to give the information.

Mr. Millar then stated that he had succeeded in getting nine gentlemen to give estimates as to the effect of the ceiling and walls upon the illumination of a horizontal plane three feet above the floor. He was only able to get them to give estimates on the percentage of increase in illumination which the ceiling and the walls would produce in addition to the lighting from the lamps direct. The table in the paper shows that, by actual measurement, this proportion of increased illumination due to the ceiling and the walls varied from 45 to 166 per cent with different locations of lamps. The estimates made by practical illuminating engineers were as follows:

15 per cent, 20 per cent, 33 per cent, 60 per cent, 33 per cent.

Estimates from electrical engineers were as follows:

100 per cent, 10 per cent, 100 per cent.

A physicist who happened along at the time gave his estimate as 60 per cent, and a fixture manufacturer estimated it as 30 per cent. He considered that it was a pretty good indication of the necessity for careful measurement of illumination after it has been laid out, and a demonstration also that, at least today, we are not able to estimate this with sufficient accuracy for practical purposes.

Mr. Porter asked Mr. Millar if any of these gentlemen took into consideration the difference in the increase due to diffusion between the different systems of light?

Mr. Millar replied that two of the illuminating engineers did raise that point, and then following it up changed their estimates a little for different locations of lamps, but in both cases their change was in the wrong direction.

Dr. Sharp, referring again to the subject of reflectors, said that Dr. Dennett remarks regarding the geometric optics of the parabolic reflector were quite true, if you take only one point; but if you take even the smallest light-source you have an infinite number of points; in other words, you have a surface, and the beam of light which you get from a projector cannot be a beam of parallel rays, but will diverge, and therefore decrease with the distance, unless brought to a focus; and then between the projector and the focus the intensity of the beam increases, and beyond that point it decreases. So that if you adjust your reflectors as nearly as you can to give parallel rays, the beam is really divergent, on account of the fact that you have not a point source of light; consequently if you go far enough away you will encounter the law of inverse squares; but you have to go a long way off.

Dr. Dennett remarked that if it is practically a parabolic reflector it is so near the ideal conditions that the law of inverse squares does not count for much, because the beam increases in such an indefinitely small ratio as to give practically the same result. If the ideal conditions are not near enough to work with some degree of approximation to what they ought to be, you should not call it a parabolic reflector, because that is not what you are using.

Mr. Elliott said that a year or two ago the question suggested itself to him whether concentrating reflectors, either parabolic or conical, would give a sensible variation from the law of inverse squares, at least enough so as to throw out such calculations from the ordinary accuracy that would be required in illuminating engineering; and in order to bring the matter to a practical test he had a series of experiments carried out in a private laboratory with a number of reflectors, and to his surprise he found that the law of inverse squares held for all distances for which a reflector would be practically used. The size of the ordinary light-source, such as an incandescent lamp, and the variation of the shape of the reflector, are so wide from the theory that, in practice, illuminating engineers can stick to the law of inverse squares.

The President suggested that it would be very interesting to make a series of tests similar to those recorded in Mr. Millar's paper, but in a large room. It occurred to him that, while the results are of the greatest importance, in the case of a very large room their usefulness might not be so great, and he hoped that Mr. Millar would, in a subsequent report, add measurements of that character to what he had already given.

Mr. Millar, being called upon to close the discussion, said: Major Zalinski said that in connection with measurements or distribution of light about diffusing reflectors he now sees in this paper comparative data obtained with opal and other reflectors. If such a comparison could have been drawn the data could not have appeared in this paper. I want it to go on record very emphatically that the conditions are so dissimilar that it would be improper to attempt to draw any comparison whatever between the different lighting conditions used.

In Mr. Williams's statement regarding the new high-efficiency lamps, he said that the major portion of the light was distributed horizontally and almost none through the tip. I think he is giving rather a wrong impression there. There is a difference, it is true, between the present and the old forms, but it is not a very wide difference.

As to the remarks on the question of the applicability of the inverse squares law to reflectors, it seems to me that it depends altogether upon the nature of the reflector. I cannot agree with Mr. Elliott that illuminating engineers will do well to stick to the law of inverse squares for the time being. One of the chief difficulties in applying the law of inverse squares is that we have as a result measurements at different distances. This means then that comparisons between different reflectors are not likely to be valid when based upon photometric measurements, if it is the case that for some reflectors the law does not apply; and with the usual photometric practice we are absolutely ignorant of the exact distance at which the various settings are obtained.

Papers Read Before Technical Societies

THE MERCURY ARC: ITS PROPERTIES AND TECHNICAL APPLICATIONS.

By E. Weintraub, Ph.D.

Read before Franklin Institute, March 22, 1906. Reprinted from *Journal*.

Section I.—*Structure of the Mercury Arc.*

We understand in what follows by "Mercury Arc" an arc through mercury vapors in a perfectly exhausted space.

The *structure* of this arc varies with the conditions, such as temperature, pressure of the mercury vapor, etc. In general, we can distinguish (1) a *homogeneous* part, beginning at the anode and ending at a certain distance from the cathode. This part is similar to the positive column of the ordinary Geissler discharge. We will designate it, therefore, by the name Positive Column of the Mercury Arc. (2) In the neighborhood of the cathode and following the positive column a *relatively dark space*, similar to the cathode dark space of the Geissler discharge. (3) Finally, at the cathode itself a bright patch which we will call the *cathode spot*. This spot is usually in irregular motion on the surface of the cathode.

The most important deviations from this normal structure can be summarized as follows:

(a) The cathode dark space is the more developed the larger the diameter of the tube at a given current, or, in other words, the smaller the current density. In narrow tubes at high current densities the cathode dark space disappears completely. (b) If the mercury vapor pressure in the arc space gets above a certain value the positive column no more fills the entire section of the tube, but rather concentrates itself in the middle of the tube, being surrounded on all sides by a space of relatively weak luminosity and very small conductivity.

If the mercury arc is to present its normal appearance, such as described at the beginning, the mercury vapor pressure must be kept below a certain maximum value. This can be achieved either by regulatinig the dissipation of heat from the surface of the arc itself, or eelse by providing a chamber lying outside of the path of the arc in which the mercury vapor can condense. This part of the tube will be designated by the name "condensing chamber."

In the description of the different parts of the arc that follows we will assume that we have to deal with an arc of normal structure.

1. *Anode.*

The anode of the mercury arc can consist of any conducting material of sufficiently high melting point which does not combine with mercury. In practice, only three materials are in use, mercury itself, graphite and iron (or nickel).

When mercury is used the distribution of current at the surface is, under normal conditions, uniform all over. Only when the mercury vapor pressure goes up above the permissible limit does the distribution become more or less localized, the arc leaving the surface mostly at the side nearest to the cathode. The heat evolved at the anode is used up in volatilizing the mercury. This increases the pressure of mercury vapor in the tube and larger condensing chambers are necessary to keep the pressure down to its normal value.

If graphite or iron are used as anodes, the arc usually leaves the anodes at those parts which are nearest to the cathode. The heat evolved at the anode serves to increase its temperature and the resulting temperature is the result of an equilibrium between two factors, the production of heat at the anode and the conduction of heat by the mercury vapor surrounding the anodes. It increases with the current and its upper limit is only determined by the melting point or boiling point of the material. The heat evolved at the anode is due to the existence of a certain potential drop at the surface of contact between the anode and the arc. The magnitude of this "anode polarization" depends on the material used, its temperature, and is therefore not a characteristic quantity.

2. *Positive Column of the Arc.*

The positive column presents in the normal arc a uniform appearance, with no striations whatever. Only in the case of very small current and seemingly *only in the presence of foreign gases* do striations appear. This case is interesting, as in contradistinction to the Geissler discharge, the straitions appear here at low voltage. The potential drop in the positive column has a certain value per unit length and is the smaller the larger the diameter of the tube. A *simple* relation between the diameter and the drop does not exist. In a tube of 1.8 cm. diameter the potential drop per cm. is equal to about 0.72 volt. The potential drop depends, of course, on the pressure of the mercury vapor in the tube. The above given value refers to a good vacuum and to the case when the pressure of mercury vapor is kept low by a condensing chamber, but no exterior cooling means are used. The drop per unit length in the positive column, being thus variable, is not a characteristic quantity of the arc.

Section II.—*Properties of the Cathode.*

The properties of the cathode are of such

importance that a special chapter must be devoted to them. The processes going on at the surface and in the neighborhood of the cathode are essential both for the maintenance and for the initial starting of the arc.

(a) The following experiments will show the role of the cathode in the *starting* of the arc:

The tube *ABC* (Fig. 1) has two cups, *B* and *C*, filled with mercury, and a graphite electrode *A*. *B* and *C* are connected to one source of direct current, *B* and *A* to another; let us imagine that the connections are made at first in such a way that *B* is the common *negative* pole of the two sources. If the electrodes *B* and *C* are brought into contact and separated the arc *BC* starts, *B* being its cathode. We find then that on closing the switch of the circuit of the other generator, G_1, the arc *AB* starts instantaneously.

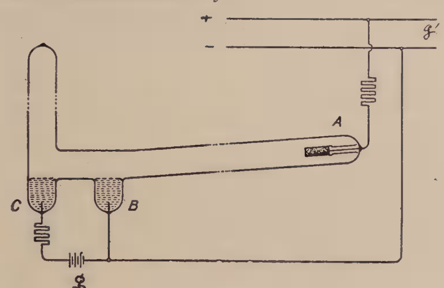


FIG. 1.

If the connections are changed in such a way that *B* is the common *positive* pole of the two sources and the arc *BC* started as before, the arc *AB* does not start on closing the switch. This *dissymmetrical* behavior shows how entirely different the electrode *B* behaves when it is cathode and when it is anode of an arc.

The experiment succeeds also when the graphite anode *A* is replaced by a mercury electrode. In this case, however, the arc *AB* may sometimes start up, even when *B* is anode, for the reason that the mercury cathode *A* can be rendered active by other causes than by an already existing arc.

Since ordinary mercury vapor is a nonconductor and since the experiment described shows that the excitation of the cathode by means of the auxiliary arc *BC* is necessary for the starting of the arc *AB*, we are forced to the conclusion that *the production of the conducting vapor takes place, at least in the very first stages of the development of the arc, at the surface of the negative electrode.*

In the ordinary process of starting an arc by contact it is impossible to separate the function of the cathode from that of the anode. The experiment described above represents for an arc in vacuum such a separation and shows the complete difference between the behavior of the cathode and that of the anode, a difference which is of fundamental importance for any theory of the arc discharge.

The experiment succeeds well only when the vacuum is very good, i. e., in absence of foreign gases, and also in absence of too large an excess of ordinary mercury vapor. In other words, the experiment succeeds well at ordinary temperature in a perfectly exhausted tube, the anode and the walls of the tube having been previously freed from all gases absorbed on their surface. If the vacuum is not perfect or if the tube is hot, so that too much mercury vapor is present, the starting of the arc *AB* is not instantaneous and one can see the conducting ("ionized") vapor spreading slowly from the cathode *B*. When this ionized vapor reaches the anode *A* the arc *AB* usually starts, although if the vacuum is too poor the starting may not take place.

(*b*) *Role of the Cathode in the Maintenance of the Arc.*

In the chapter on the stability of the mercury arc we will see that under given conditions there exists a minimum value of current at which the arc is stable and below which it goes out. Under ordinary conditions this minimum value lies at about three amperes. Experiments have shown that the instability of the arc below the minimum value is due, to a large extent, to the *wandering* of the cathode spot on the surface of the mercury cathode.

The fact that there exists a bright patch on the cathode and that this patch constantly and irregularly wanders about on the surface of the mercury has already been mentioned above. The cause of the wandering has not yet been ascertained.

This wandering can be avoided in two different ways. The first way consists in the use of a platinum or iron wire protruding above the surface of the mercury. If the current is not large, say not above five amperes, the cathode spot fixes itself around the wire at the point where the wire crosses the mercury surface. The second way consists in the use of a narrow tube of refractory material, such as silica or porcelain, the cathode spot being produced by means to be described later (Section 3) on the mercury surface inside this narrow tube. In this case the spot remains always inside of the tube.

Now, if the cathode spot is fixed by either of these two methods, the value of the *minimum current is considerably lowered.* In the case of a narrow silica tube surrounding the cathode spot, the value of the lower limit is about 1½ amperes; in the case of the platinum wire about .9 ampere. This result, viz., that the wandering of the cathode spot on the mercury surface causes the arc to go out, is again a strong argu-

ment in favor of the theory that the production of the current carrying material takes place in the cathode spot, every disturbance of that process, such as is caused by the wandering of the cathode spot, being able to stop that process altogether.

(c) *Polarization of the Cathode.*

At the surface of the cathode there is a potential drop equal to about five volts. This quantity is independent of the current, mercury vapor pressure, etc. The polarization voltage at the anode, as well as the drop in the arc itself, were shown to be variable quantities.

The cathode spot is the larger the larger the current. It is quite possible that when the current is such that the cathode spot covers the whole surface of the cathode, further increase of the current would change the value of the cathode potential drop.

(d) *Disintegration of the Cathode.*

It is possible to realize mercury arcs, that is, arcs through mercury vapors in an exhausted space, with a cathode consisting of any conducting material. If in the tube *AB* (Fig. 2) the graphite electrode *A* is connected to the negative pole of a direct current circuit and *B* to the positive pole, and the electrodes brought into contact by

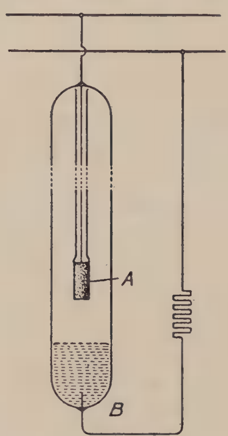


FIG. 2.

shaking, an arc starts with the graphite as cathode. These solid cathodes, as I will call them, for the sake of brevity, show the same behavior with respect to the starting of the arc as an ordinary mercury cathode. Thus the fundamental experiment described in the beginning of this Section can be repeated with a solid cathode. [*B* (Fig. 1) is made of graphite, iron or any other conducting material.] Care, of course, must be taken to free that electrode from absorbed gases before trying the experiment. With these solid cathodes another phenomenon, however, is observed, viz., the *mechanical disintegration of the material of the cathode.* The cathode spot exists also on the solid cathodes. A well defined and sharply outlined red hot spot wanders irregularly on that surface and at the same time small particles of the material are being incessantly projected from that spot, collecting on the walls of the tube. *This disintegration of the cathode represents another essential difference between the anode and the cathode of the arc in metallic vapors in an exhausted space.* In the case of one material, viz., of charcoal, one succeeds in obtaining on the surface of the electrode *sharply outlined, fine grooves which show the path followed by the cathode spot.* Measurements of the dimensions of these grooves, their width and depth at different currents under different conditions, might lead to interesting conclusions. In the case of all other materials every particle disintegrated electrically causes, by loosening the structure, other particles to separate mechanically in such a way that no trace of the cathode spot is left on the surface. The material produced by the disintegration of the cathode differs usually in its physical properties from the original material of the cathode. If graphite, for instance, is used, the disintegrated material has no cohesive properties, is a very poor conductor and leaves no trace on paper. The chemical properties, however, remain the same.

SECTION III.—*Starting of the Mercury Arc.*

The methods usually used to start an arc can be described as the *"contact" method* and the "high potential" method.

In the first method, which is used in the carbon arc, in flame arcs, etc., the arc is started by bringing the two electrodes into contact and separating them.

The second method consists in sending for a short time a discharge from a high potential source through the space between the two electrodes and then making the low voltage source follow the path of the discharge of the high potential. (This method was, I believe, first used by Herschel.) Both methods have been used in the case of the mercury arc by Arons, Cooper Hewitt, myself and others.

In the case of the mercury arc the contact method has taken different forms. Arons used a U shaped tube, the tube being partially filled with mercury and the two mercury surfaces brought in contact by shaking. In another arrangement one of the legs of the tube is long and connected at its lower end by means of a rubber tube to a vessel filled with mercury. By lowering or raising this vessel the two mercury surfaces can be brought into contact and subsequently separated.

One form I gave to this method is that of a straight horizontal tube, with two cups filled with mercury. By inclining the tube

a stream of mercury is caused to flow from one electrode to the other and this establishes contact for a short interval of time. This movement of the tube can be produced automatically by a current flowing through magnets in shunt with the tube.

A similar arrangement has also been used by Cooper Hewitt, the shaking of the tube being done by hand. It is obvious that a number of other ways can be found, such as heating the mercury and causing it to expand, etc., all for the purpose of bringing the two mercury surfaces in contact.

The high potential method has been used by Arons and then afterwards by Peter Cooper Hewitt.

A "kicking" coil and a quick break switch are placed in shunt to the mercury tube. On opening the quick break switch the high potential created at the end of the reactance discharges through the space between the electrodes in the mercury tube, whereupon the low voltage follows in the path of the discharged and establishes an arc.

The Sidebranch Method—Excitation of the Cathode.

The new method for starting the mercury arc that I proposed is founded on the cathode properties which have been described in the previous chapter. We have seen that if the negative pole, which is to be the cathode of the arc, is excited by an auxiliary arc and the vacuum in the tube is good, an arc will instantly establish itself between this cathode and any anode.

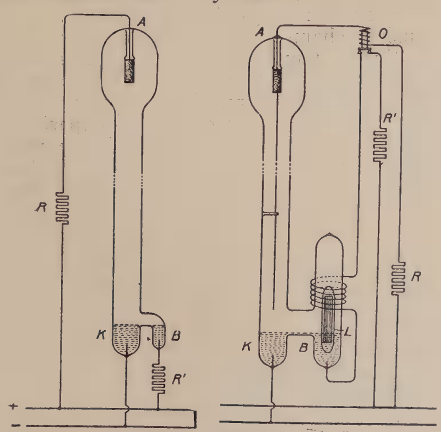


FIG. 3 AND 4.

The tube represented in Fig. 3 shows one of the ways in which this property can be used for the purpose of starting an arc. *K* represents a mercury surface connected to the negative pole of the source of direct current. *A* represents the electrode which is to be the anode of the arc. *B* is also connected to the positive pole of the source of direct current. *R* and *RA* are two resistances. If by slight shaking of the tube the electrodes *K* and *B* are brought into contact and separated, a short arc is formed which excites the cathode *K* and causes the starting of the main arc, *AK*. The auxiliary arc, *KB*, can then be extinguished by opening a switch in the line of the auxiliary anode *B*. The side tube *KB* is called "the sidebranch," *B* the auxiliary or "starting" anode, and the method of starting is called the *"sidebranch method."* The auxiliary arc, *KB*, instead of being started by shaking, can, of course, be started automatically in many different ways; one of the first used is shown in Fig. 4. The mercury surfaces of the cathode *K* and the auxiliary anode *B* are normally in contact, *S* is a solenoid, *L* a bundle of iron wire. The current, on closing the switch in the line, goes through the solenoid and the mercury in *B* and *K*. The iron core *L* being lifted, the contact between *KB* and *K* is broken, whereupon the little arc *BK* starts the main arc *KA*. *O* is a magnetic cut-out which opens the circuit of the side-branch when the current in the main arc reaches a given value.

Besides this arrangement, a number of others for the purpose of automatic starting of the sidebranch were used; they are, however, not as simple as the electromagnetic one just described.

The starting of the arc by means of the sidebranch method is instantaneous only when the vacuum of the tube is exceedingly good and the pressure of the mercury vapor is not too high. The starting of the main arc is accordingly instantaneous when the tube is perfectly cold or immediately after the arc is put out. If the vacuum is not perfect or the tube hot, the starting of the main arc takes some time. This is the same phenomenon as that which we described in the paragraph on the properties of the cathode and would suffice to make the practical value of the sidebranch method of starting rather small. The difficulty has, however, been overcome by suspending from the anode a carbon filament of high resistance and of such a length that its lower end is but a few inches away from the mercury cathode. For the starting of the arc this means a shortening of the distance between the anode and the cathode. After the arc is started a very small current only flows through the carbon filament, the arc having a much lower resistance. The filament is seen in Fig. 4.

Out of the use of this carbon filament as a device for the facilitating of the starting of the mercury arc, another method of starting developed. The carbon filament instead of reaching within a certain distance from the cathode, actually touches the latter, so that, on closing the switch, the current finds a way from the anode to the cathode, through the carbon filament. This current is caused by energizing a solenoid,

to separate the filament from the mercury cathode, either by lifting the filament or by lowering the level of the mercury. The little arc thus formed between the end of the filament and the mercury cathode instantaneously develops into the main arc between the mercury cathode and the anode. An arrangement in which the carbon filament is lifted is shown in the next sketch (Fig. 5.)

The carbon filament is attached to an iron cylinder which forms a sliding contact with the rod *D*, which rod is directly connected to the leading-in platinum wire. The current at first flows through the solenoid *S*, the leading-in platinum wire, carbon filament, mercury cathode, back to the source. The energized solenoid in pulling up the iron cylinder to which the carbon filament is attached starts the arc. In some of the arrangements the upper part of the rod *D* is coated with an insulating layer of glass, so that when the sliding cylinder is pulled up, the current flow through the carbon filament completely ceases and the carbon filament is cut out of circuit. This lamp is given the name of the "Lift-Up Filament Lamp."

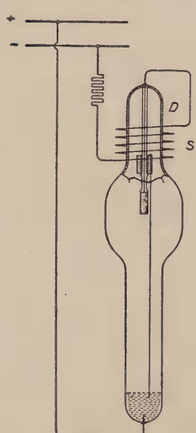


FIG. 5.

An arrangement in which the mercury level is lowered was designed by C. P. Steinmetz. An iron plunger, the upper part of which is drilled out and carries mercury in the hole, floats in the mercury cathode so that in the normal condition the filament is in contact with the mercury in the plunger. A solenoid, when energized by the current, pulls the plunger under the surface of the mercury and by breaking contact, starts the arc. This type of lamp is called the Plunger Lamp.

SECTION IV.—*The Stability of the Mercury Arc.*

The conditions of stability of the mercury arc are of a rather complicated nature and depend on a number of factors. We shall limit ourselves to the consideration of the two most important cases.

First. *Mercury Arc with a Condensing Chamber.*—We shall first consider the arc placed in a space of ordinary temperature and *provided with a condensing space, certain parts of which remain at a temperature not much above the surrounding temperature.* The mercury arc such as is used for purposes of illumination, belongs, with a few exceptions, to this type.

In this case the potential across the arc at first diminishes as the current increases, until a certain point is reached above which the variations of potential and the current have the same sign. The potential drop across the lamp meant is not the one which is established immediately after the current is changed, but rather the one which corresponds to the equilibrium, the equilibrium being reached only after a certain time. Let *A* be the value of current which corresponds to the minimum value of the potential drop across the arc. Then it is obvious that for currents below the one corresponding to *A* the arc is in an unstable condition, since to a slight diminution of current there corresponds an increase of voltage across the tube, which causes in its turn a diminution of current, the process going on until the voltage drop comes near to the impressed voltage and the arc goes out.

For currents above the value *A* the arc is in a stable condition (the current being, however, not too high, since then the condensing chamber is no more at a sufficiently low temperature). These considerations show that there exists for a normal arc a minimum current below which the arc is unstable and goes out. The experiment confirms this result. That minimum value is usually in the neighborhood of three amperes. This explanation of the existence of a minimum current, although in all probability correct from a formal point of view, does not give us any insight into the physical cause of the phenomenon. This cause was partly pointed out in Section 2.

In all the considerations given above it was assumed that a certain regulating resistance is in series with the arc, but no reactance. If a large reactance is placed in series with the mercury arc it changes the conditions of stability altogether. This is similar to what was known in the case of the ordinary carbon arc. With a large reactance in series the minimum current at which a normal arc can run is much lower than without reactance and is the lower the larger the reactance. With a sufficiently large reactance it is easily possible to have an arc with a current of only a few tenths of an ampere. The action of the reactance, which consists in introducing an e. m. f. every time the current tries

to diminish, is too obvious to require any discussion.

Second. *The Arc Without a Condensing Chamber.*—If the arc is not provided with a condensing chamber its stability depends a good deal on the conditions of radiation corresponding to this equilibrium and and heat conduction on the surface of the tube itself, the temperature rising until thermical equilibrium is reached between the energy input and the heat radiated from the surface of the tube. The temperature accordingly the pressure of mercury vapor in the tube being much higher than in the case of the arc with condensing chamber, the potential drop across the arc is considerably higher, and the curve connecting this potential drop with the current is also different. It is, however, possible to have an arc run stable under these conditions by a proper choice of the impressed e. m. f., the resistance in series with the arc and the external temperature.

SECTION V.—*Arcs in Metallic Vapors Other than Mercury.*

The arc in the vapors of other metals which are sufficiently volatile, has in general the same properties as the arc in mercury vapors. The investigation included the following metals: Potassium, sodium, alloys of the two as well as with lithium, bismuth, lead, tin, zinc, cadmium and alloys of those metals which have a low melting point, such as Wood's metal, finally amalgams of all the above-named metals, etc. In most cases the arc was produced inside of a glass vessel, although in the case of the less volatile metals a silica vessel was often used, the silica vessel containing the metal and being suspended inside of a glass tube or bulb. In the case of the alkali metals and of the easily fusible alloys of the other metals, such as Wood's alloy, etc., it is easily possible to produce in a well exhausted tube arcs of practically any desired length. Those arcs have essentially the same properties as the ordinary mercury arc. A cathode spot exists on the surface of the metal, whether this metal be liquid or solid. This cathode spot is wandering about the surface and all the experiments that have been described in the case of the mercury arc can be repeated here. The anode can be made of any material and consisted in the experiments mostly of a piece of graphite.

The spectrum emitted changes of course with the nature of the metal. The amount of light is usually small and the efficiency small. This is due to the small amount of material in the space, in consequence of the low vapor tension of these metals. If the exhaustion is made by means of a mercury pump the small amount of mercury vapor present in the space is sufficient to give to the arc immediately after starting the character of a mercury arc. As the material of the cathode volatilizes the mercury vapor spectrum is being replaced by the spectrum of the corresponding metal.

If amalgams are used the spectrum of the arc shows lines due to the mercury as well as to the metal dissolved in it. The proportions in which the radiations of the two metals are represented in the spectrum depends, of course, on the percentage of the metal dissolved in the mercury. It also depends on the current. When dilute amalgams of alkali metals are used the lines due to sodium or potassium begin to appear only when the current reaches a certain value. The addition of the alkali metals or of the metals like calcium strontium, link, etc., could be used for the purpose of improving the color of the light emitted by the mercury arc. (See Section Technical Applications.)

The drop of potential across the arc, as well as the single drops at the electrodes, are of the same order of magnitude whatever the metal used.

SECTION VI.—*Alternating Current Phenomena in the Mercury Arc.*

Alternating voltages of moderate value are incapable of maintaining an arc in mercury vapors in an exhausted space. The spark formed on separating the two electrodes dies out, no matter how large the current it carries.

This phenomenon is easily accounted for on the basis of the principles laid down in the section on the cathode properties. An arc cannot exist without a constant source of conducting material at the negative electrode. If the production of conducting material ceases at the cathode, the arc is bound to go out, unless by some means the cathode surface is rendered active anew. In the case of an alternating voltage, however, the negative pole changes from one mercury surface to another. The emission of negative ions which is started by the initial separation of the electrodes dies out and with it the arc. The conditions change when the alternating voltage is high enough to render the cathode active at each alternation. This we will discuss later; we limit ourselves here to the case of an alternating voltage of moderate value.

In this case, one way of making a *current derived from an alternating source pass through mercury vapors is to keep one of the electrodes active by making it the cathode of an auxiliary direct current arc.* The arrangement is the same as on Fig. 1, with the difference that g^1 is an alternator.

CB is a direct current arc with *B* as cathode. *B* and *A* are connected to the terminals of a source of alternating voltage. The electrode *B* being constantly kept active by the direct current, the half wave of the alternating voltage, for which *B* is the negative pole, can send a current through the space

between *B* and *A*. The half wave of opposite sign cannot pass. Accordingly, we get in the cirucit of *BA* a pulsating unidirectional current. The interest of this arrangement is obvious, as it gives us a way of deriving unidirectional, although pulsating current from an alternating source.

By providing two auxiliary direct current sources and connecting the alternating current source to the two cathodes of the direct current arcs, an *alternating* current can be made to pass between those two cathodes. The discussion of this case, in spite of its interest, I must omit, in order not to make this article too voluminous.

Returning to the first arrangement, in which only one direct current source is used, we see that a pulsating current is derived, only one half wave being utilized. To utilize both half waves and superimpose them in the same direction in the same circuit, an arrangement can be used which is represented in Fig. 6. There are two anodes in the tube to which two terminals of the secondary of a transformer are connected. The middle point of the secondary is connected to the cathode. An auxiliary direct current source, *BK*, serves to excite the cathode. As is easily seen, for each direction of the alternating voltage one half of the secondary sends a current through the tube in the right direction—that is, in such a direction that *K* is cathode. The current derived in the wire connecting the cathode to the neutral

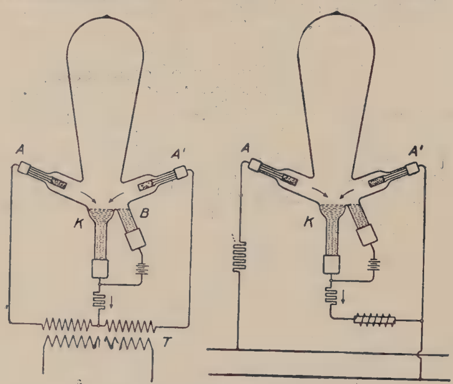


FIG. 6 AND 7.

point of the transformer consists now of an uninterrupted series of pulsations. It passes through zero every half period and the auxiliary direct current source has only the function of keeping the cathode active during those intervals of time when the alternating current is zero or in the neighborhood of it.

The use of a direct current for the excitation of the cathode can be dispensed with *if the property of reactances* of accumulating energy when the current flowing in them increases and discharging that energy when the current begins to diminish, is *made use of*. A rectifier constructed on this principle and in which only one half wave is rectified, is shown in the next sketch. (Fig. 7.)

The electrodes *A* and A^1 are connected to the two poles of the alternating current source. Between A^1 and the middle electrode *K*, a reactance coil is placed. If by any means *K* is made for an instant cathode, either by an auxiliary direct current or by preliminary contact of *K* with *A*, the following processes go on: The half wave for which *A* is anode passes in the direction from *A* to *K*, then through the reactance and when this current begins to diminish, the reactance discharges mostly through the space A^1K in the direction shown by the arrow. If this discharge takes a sufficiently long time, the cathode is kept going during that half period, when otherwise there would be no current.

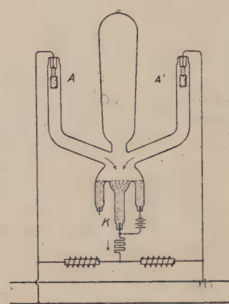


FIG. 8.

To get both half waves rectified by the use of reactances, the arrangement shown above must simply be made symmetrical by the use of two reactance coils, in the way shown in the next sketch (Fig. 8.) It will be seen that both half waves, as well as the discharges of the reactance coils, have the same surface, *K*, for cathode, and that in the wire connecting the cathode to the point between the two reactance coils a continuous direct current is flowing. The load, which can consist of a resistance or storage battery, etc., has therefore to be placed in this line.

It will readily be seen that the result achieved in the last arrangement by the use of two reactance coils can also be achieved in the arrangement described above (Fig. 6), where the neutral wire of a transformer is used by simply introducing a sufficiently large auxiliary reactance into the neutral wire between the middle point of the transformer and the cathode.

SECTION VII.—*Arcing.*

The two electrodes, A and A^1, in the rectifier described last, the anodes of the rectified currents, are, when the arcs run, surrounded by highly conducting vapor and it is at first glance surprising to find that

no arc develops between them. The absence of an arc discharge directly between the two anodes is easily accounted for on the principles expounded above by the absence of a cathodic center on either one of the two anodes. If such a cathodic center is for one reason or another formed on one of the two anodes, an arc discharge between the two anodes takes place, and this phenomenon was termed "arcing of the rectifier." In absence of such a cathodic center a very small "leakage current" probably exists between the two electrodes (since one always finds currents of the order of magnitude of 1 milliampere between two exploring electrodes placed in the mercury arc and to which an e. m. f. of moderate value is applied.)

The conditions under which this leakage current develops into an arc discharge—in other words, the conditions under which in presence of conducting vapor, a cathodic center is produced on a negatively charged surface, are of considerable theoretical interest. The following experiments are of interest in this connection:

Let us return to the experiment by means of which we illustrated the importance of the cathode in the starting of the mercury arc. The tube is the same as that represented on Fig. 1 and the connections are also the same as there. The only difference is that the anode *A* is made of *mercury* instead of graphite. The phenomena described in the corresponding paragraph remain the same, whatever the material of the anode. If *B* is made cathode by starting the arc *BC*, the arc *AB* starts up instantaneously (provided there is a good vacuum in the tube.) If the electrode *B* is the common anode the arc *AB* does not usually start. However, when the ionized vapor which diffuses from the arc *CB* fills the space between the electrodes *B* and *A*, a small leakage current between *A* and *B* takes place. If *A* is graphite or iron this state continues indefinitely. If *A* is mercury the arc may eventually start between *B* and *A*, *A* becoming the cathode of the new arc. The experiment can be given even a more effective form by placing the cup *A* between the electrodes *B* and *C*. In that case, in spite of the presence of the highly conducting vapor of the arc *C*, a small leakage current only exists between *A* and *B*. It is, however, more difficult to maintain this condition and the arc starts rather readily.

In these two experiments with direct current arcs we are therefore confronted with the same problem of the formation of a cathodic center on the surface of a negatively charged body. The experimental results obtained in the study of this question, the practical importance of which is obvious from the connection with the arcing of the rectifier, can be summarized as follows:

(a) The ease with which a cathodic ionization center forms on the surface of a negatively charged electrode varies with the material of which that electrode is made.

The ease of formation seems to be connected with the boiling point of the material, and is, therefore, unless certain necessary precautions are taken, greater in case of mercury than in the case of solid electrodes.

In the rectification of very high potentials such as given by an ordinary induction coil or high potential transformer (say 30,000 to 40,000 volts) and very often also in the rectification of voltages somewhat below (around 10,000) the influence of the material on the ease of the formation of a cathodic center is shown in a very striking way. The graphite anodes are usually fastened by means of leading-in platinum wires, which are insulated either by a coat of glass or by glass tubes surrounding them. Experiments show that at the high voltages mentioned above, a cathode center is more *liable to form on the glass which surrounds the platinum wire than on the graphite.* A bright cathode spot appears on the glass, causing it to melt and volatilize. The gases evolved spoil the vacuum, and the cracking of the seal often destroys the tube. The fact that on glass and similar materials the cathode spot forms more readily than on graphite or iron is again probably connected with the fact that glass can give off vapors of sodium and similar metals.

(b) *The Influence of the Potential.*—It is natural that the formation of the cathode center takes place the more readily the higher the potential applied. In fact, one of the older methods of starting a mercury arc by the "kick" of a large inductance is based on the formation of a cathode center under the influence of high potential.

In the case of the mercury arc rectifier the danger of arcing between the two anodes increases as the voltage applied to the anodes increases. With graphite anodes if necessary precautions are taken, the upper limit of potential at which arcing takes place has not yet been determined.

The formation of a cathodic center on a negatively charged mercury surface under the influence of high potential can be shown by the following experiments:

(1) Let *AB* (Fig. 2 only with reversed connections) represent a tube in which *B* is a mercury surface connected to a negative pole of a source of unidirectional low voltage and *A* is a graphite anode connected to the positive pole of the same source. If the distance between *A* and *B* is not too large (in some of the experiments it was, however, as large as 8 to 10 inches) mere shaking of the tube is apt to start the arc between *A* and *B*. It is obvious that the mechanical shaking can act only by produc-

ing a static charge of high potential on the surface of the mercury.

The next experiment seems to show that a considerable factor is the electric field intensity near the cathode.

(2) A tube *AB* has two mercury electrodes. One is of a very small surface, the other of a very large. On connecting these two electrodes to the secondary of a high potential transformer, cathode spots appear in the form of sharp, brilliant points only on the small surface, provided the current in the tube is kept low. This is explained by taking into account the different shape of the mercury surfaces constituting the two electrodes. The radius of curvature being much smaller in the case of the small electrode and accordingly the field intensity higher, the negative particles are propelled with greater force into the space and a cathode center forms more readily. If a direct current ammeter is placed in the circuit of the tube its reflection shows that rectification takes place. The direction in which the current predominates is, however, not necessarily the one for which the small electrode is cathode. At very small currents the current of opposite direction usually predominates showing that the negative current, which leaves the large surface *B* in form of a *homogeneous* discharge, equally distributed over the whole surface, is larger than the negative current, which leaves the small surface in localized cathode points. As the current is increased the two opposite currents become equal, and when the cathode points on the small electrode grow sufficiently large, the negative current starting from them begins to predominate. If cathode spots form, as they often do, on the large surface *B*, they usually form in the neighborhood of the glass, at the place where the curvature of the mercury surface is smallest and the electric force perpendicularly to the surface accordingly the highest.

(c) *The Influence of the Position of the Anodes with Respect to the Cathode.*

We come here to a phenomenon which is surprising and the cause of which is not yet certain. The ease with which the cathodic center forms on one of the anodes of a high voltage rectifier depends on the relative position of those anodes with respect to the cathode. If the anodes are placed directly above the cathode arcing takes place more readily than if the anodes are placed at a certain angle to the perpendicular erected on the mercury surface and the danger of arcing is the smaller the larger that angle. If of the two anodes one is placed perpendicularly above the mercury cathode and the other either at a certain angle or even below the mercury level, the arcing, if it does take place, invariably has its cathodic point on the anode which is directly above the cathode. It seems as though the ionized vapor that usually shoots out from the surface of the cathode in a perpendicular direction (and is probably of an origin similar to the cathode rays) has some peculiar effect on the surface of the anode which facilitates the production of a cathodic center of ionization.

Section VIII.—Technical Applications.

I. *The Arc as a Source of Light.*

The luminous efficiency of the mercury arc in any of the forms described in Section III is quite high. Measured with a flicker photometer, which is the only one allowing comparison of lights of different color, this efficiency varies under different conditions between say .25 to 1 watt per candle, the watts meaning the consumption of energy in the arc itself. Under ordinary circumstances about 20% of the watt consumption in the arc is wasted in the ballast resistance (except in series lighting where no resistance is necessary) and some part of the light is also absorbed in the globe by which the arc itself must usually be surrounded. The physiological effects of the light on the human eye and the distribution of light being of different nature than in most other sources of artificial light, the above given numbers are of considerably less practical value than actual experiments made for instance with the luminometer—that is, an apparatus by means of which the distinctness of objects at a certain distance from the source can be approximately determined. These experiments show also that the mercury arc is a highly efficient source of light.

The life of the mercury arc lamp in one of the shapes described in Section III is very considerable, in some cases amounting to 3000 hours and more. In the course of time the glass of the tube in which the arc is enclosed blackens somewhat (in consequence of a chemical change in the glass) and in lamps with a carbon filament usually some blackening takes place, due to a deposit of carbon on the walls. This blackening causes a diminution of efficiency in time which amounts to about 20% at the end of the life.

The lamp needs no attendance, as there are no electrodes to replace.

Other advantages of the lamp are the fact that relatively small units can be made (the units now made consuming 160 watts) and the diffused distribution of light in contradistinction to the concentrated sources of light represented by other arcs.

All these advantages would certainly cause this lamp to be an important factor if it were not for the nature of the light emitted, which is practically devoid of red rays. In spite of this, the lamp is being used and will probably be used more and more extensively for purposes where this absence of red rays and the corresponding discoloration of objects is of little import-

ance. In street lighting, the lighting of parks and suburbs, as well as of factories, drafting rooms and similar places, the lamp seems to be very suitable. The mercury arc lamp is essentially a direct current lamp. An alternating current lamp was also constructed and used, built on the same principle as a mercury arc rectifier, the starting device being similar to that used in the case of the direct current arc. The construction and connections are, however, somewhat more complicated.

The methods attempted for improving the quality of the light were as follows:

(a) *The use of ordinary incandescent lamps in series with the mercury arc.* The General Electric Company has developed the so-called Orthochrome Mercury Arc Lamp, in which a number of incandescent lamps in multiple are placed in series with the mercury arc, the incandescent lamps burning at a normal efficiency. The whole is enclosed in a Holophane globe, which serves the purpose of blending the two lights of different colors. This system has, of course, a lower efficiency than the mercury arc alone and also leads to somewhat larger units.

(b) *The use of amalgams of the alkali metals and of the metals of the alkali earths.*—In Section V we saw that by adding metals like potassium, sodium, lithium, calcium, etc., to the mercury, the spectrum of the arc can be changed. The practical application for the purpose of improving the color of the mercury arc meets, however, with considerable difficulties and disadvantages of which I mention the attack on the glass by the alkali metals, the lowering of the efficiency, etc.

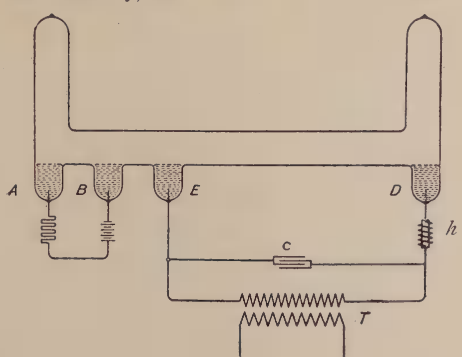


FIG. 9.

(c) *Use of fluorescent bodies which have the property of transforming the violet and green rays into those nearer the red end of the spectrum.*—Unfortunately none of the substances known possess this property in a degree sufficient for practical purposes; also this transformation is very wasteful.

(d) *Change of the nature of the discharge through the mercury vapors.*—The spectrum of the light emitted by the discharge through vapors or gases depends on the nature of the discharge. Work in this direction for the purpose of improving the color of the mercury arc has given promising results. One of the experiments, showing the essentials of the phenomenon, is illustrated in the sketch (Fig. 9.)

T is a transformer of not too small a capacity, C condensers, h a small inductance; AB is a direct current arc which supplies ionized vapor, this ionized vapor filling the space between the two other electrodes, E and D. Under proper conditions the discharge of the condenser between the electrodes E and D has a spectrum rich in red rays, the arc ED giving a brilliant white light.

II. *Use of the Mercury Arc Rectifier.*

(a) *The constant potential rectifier.*—The mercury arc rectifier represents so far the best solution of the problem of transformation of alternating to direct current, so long as the power to be transformed is not very large. The power depending on the two factors, the voltage and the current, we will consider the two separately.

The current that can be transformed by means of the mercury arc rectifier has theoretically no limit. Practically, however, one is limited by the difficulties of introduction of large currents into an exhausted glass vessel and more yet by the difficulties in dissipating the heat disengaged in the rectifier itself. Both difficulties may be overcome by a change of the material, of which the rectifier is now being made (viz., glass.)

The voltage which can be rectified by means of the mercury arc rectifier is exceedingly high. In connection with this I must refer to the section in which arcing is discussed, and from it will be seen that the voltage rectified can be the higher, the smaller the current.

The magnitude of voltage that can be rectified makes the mercury arc rectifier infinitely superior to the electrolytic rectifier.

The efficiency of the mercury arc rectifier depends on the voltage to be rectified and is the higher the higher that voltage. This is due to the fact that the voltage consumed by the rectifier itself is a constant quantity, independent of the current. In the ordinary constant potential rectifiers that loss amounts to about 17 volts. The efficiency of the mercury arc rectifier for ordinary voltages of 100 to 200 volts is therefore much higher than that of electrolytic rectifiers. The power factor can also, by a proper choice of the reactances, be made as high or higher than 90%.

The high efficiency and simplicity of the mercury arc rectifier cause its use to spread every day. It is used especially for charging storage batteries in connection with automobile and telephone work, also in a number of other cases, such as driving

small direct current motors from an A. C. source, feeding induction coils in connection with an interrupter, etc.

(b) *"Constant Current" Rectifier.*

The constant current rectifier differs from the constant potential only in the fact that a constant current transformer is used instead of a constant potential transformer. The use of the constant current rectifier in connection with direct current arc lamps especially the Magnetite Lamp, also developed in the Research Laboratory of the G. E. Co., is of growing importance. A number of installations have been made in which 25 to 75 Magnetite Lamps, each consuming 80 to 100 volts, are used as a load in the direct current side of a constant current arc rectifier, to the alternating current side of which about 15000 to 20000 volts are applied. The description of this system of lighting alone could be a subject for a separate paper, so I cannot go into detail at this place.

(c) *The High Frequency Rectifier.*

The mercury arc rectifier is capable of rectifying alternating currents of frequency as high as that given by a condenser discharge—that is, of the order of magnitude of 10^6 to 10^{10} oscillations per second. So far no limit could be found, although it is practically impossible to prove that the rectification is complete. This property can be used in connection with wireless telegraphy, the mercury arc rectifier serving to rectify the oscillations received in the antennae, and a sensitive direct curent galvanometer used in connection. The arrangement of the receiving station is represented in the sketch (Fig. 10.)

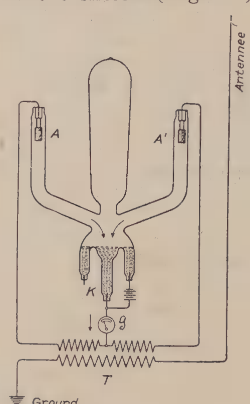


FIG. 10.

T is the transformer transforming the oscillations to higher potential and provided with a neutral wire. The connections to the rectifier are the same as those described in Section VII so that both half waves are rectified. *G* is the galvanometer. An auxiliary direct current source, consisting of a well insulated storage battery of about 20 volts, runs the sidebranch arc, so as to keep the cathode constantly active. It is probable that the arrangement is not as sensitive as a telephonic receiver. It has, however, the advantage that telegrams can be registered.

SLOWLY MOVING CATHODE RAYS AND UNILATERAL CONDUCTIVITY

(a) *Starting of the Arc.*—The experiments described in the paragraph on the starting of the mercury arc by means of an auxiliary arc may be explained by the assumption that rays similar to the cathode rays of a Crookes tube are emitted from the cathode and propagate through the space with a velocity which depends on the amount of foreign gases or mercury vapor present in the space. If the vacuum in the tube is very high these cathode rays move very rapidly and when they reach the anode a conducting bridge is established between the cathode and the anode. When the vacuum is poor, or when a great amount of mercury vapor is present, the speed of the cathode rays is reduced considerably, and through collision with the inert molecules and the recombination of the ions to neutral particles, a condition can be established such that starting of the arc is very slow or even impossible.

Besides this influence of the amount of gas present the assumption of cathode rays emitted by the cathode at the low voltage under consideration is also supported by the fact that the shape of the tube has a great influence on the starting of the arc. The starting takes place most readily when the anode is placed in a straight line with the cathode. If, on the contrary, the tube is of such a shape that cathode rays would have to change their direction a number of times before reaching the anode the starting becomes difficult. This is especially true when the cathode rays which are supposed to emanate from the surface of the mercury cathode have to impinge on glass walls or walls of similar material before reaching the anode.

Finally, the assumption made explains readily the fact that the starting of the arc in narrow tubes by means of an auxiliary arc is very difficult, and in tubes of a diameter below 1/8" practically impossible.

(b) *The Conductivity of the Mercury Vapor Diffusing from a Mercury Arc.*—If in Fig. 1 the arc is started between the electrodes C and B and e. m. f., is applied to the electrodes B and A, a certain current flows in this latter branch, even when the e. m. f. applied is below the polarization voltage which would correspond to the arc. This current has the following properties:

1. The space in the branch AB possesses unilateral conductivity; i. e., the same e. m. f. being applied, the current in one direction is much larger than in the reverse direction.

The current in the direction AB is many times larger than in the direction BA.

2. The current in the direction BA reaches saturation at very low voltage. The current in the direction AB first increases rapidly, as the voltage applied increases from zero on, then increases very slowly, until polarization voltage is reached, at which point there is a sudden transformation into an arc.

3. The current in the direction AB does not only depend on the e. m. f. applied and on the current in the arc CB, but also on the previous history of the branch AB. The current corresponding to the same e. m. f., is different when the e. m. f. is ascending and when it is descending.

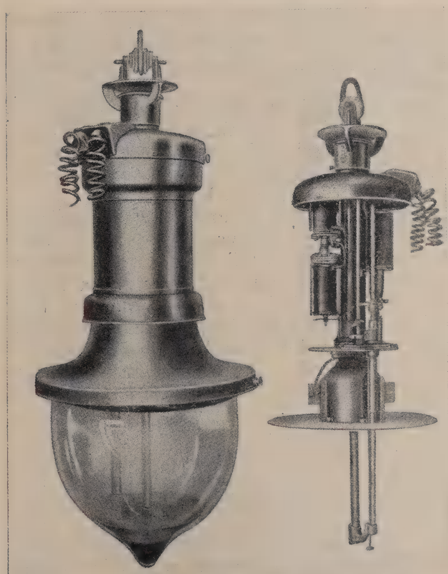
The experimental data obtained and the theoretical deductions from them would take too much space and I intend to discuss them in the future in a separate publication.

THE SERIES LUMINOUS ARC RECTIFIER SYSTEM

By N. R. Birge.

Read before the Ohio Electric Light Association at Put-in-Bay, Ohio, Aug. 23, 1906.

Central-station men are already familiar in a general way with recent developments in arc lighting, both from papers read before various societies and from discussions printed in the technical press. The new luminous arc rectifier system which is the practical embodiment of these developments represents a great advance in the art of illumination. The energy, economy, the brilliancy of illumination, and the character of distribution of the light are the marked advantages of this system.



FIGS. 1 AND 2.

The essential features of the new system are the luminous arc lamp (Figs. 1 and 2), with absolute cut-out on the line, and the mercury arc rectifier set in the station. The rectifier is supplied with alternating current, and furnishes direct current to the lamps, which are designated to operate on direct-current circuits at four amperes, with 75 to 80 volts at terminals.

THE LUMINOUS ARC LAMP.

Construction.—The main frame of the lamp consists of a single large tube which acts as a chimney for carrying away the fumes of the arc. At the top of the lamp are wind shields which prevent downward drafts into the tube.

The electrodes of the luminous arc lamp differ entirely from ordinary carbon arc-lamp electrodes. The upper electrode consists of a bar of hard drawn copper supported by iron wings. The lower electrode is made of specially prepared composition contained in an iron tube ⅝ inch in diameter, by eight inches long.

A horizontal reflector is placed inside the globe and in close proximity to the arc, and serves to throw an ample volume of light below the lamp without interfering with the main distribution of light in the horizontal direction (see Fig. 2).

The casing is made of solid copper, with oxidized finish and supports a closed base outer globe (Fig. 1), the lower part of which is frosted to ensure an even distribution of the light directly beneath the lamp.

Operation.—Referring to Fig. 3, the operation of the lamp is as follows:

The mechanism is without floating parts and when the lamp is out of circuit its electrodes are separated with the lower electrode carrier detained by a stop which holds the tip of the lower electrode at a fixed distance from the upper electrode. When the current is thrown on, the pickup by the starting magnet brings the lower electrode into contact with the upper electrode. This operation allows the current to flow through the series magnet thereby opening the circuit of the starting magnet, at the cut-out contact allowing the lower electrode to fall, striking an arc. The lamp is then burning with the lower electrode carrier resting on its stop and with the series magnet holding the cut-out contact open. As the lower electrode is consumed, the voltage across the arc rises, the shunt magnet (which is bridged across the arc) lifts its armature, closing the cut-out contact when the arc voltage has reached a predetermined limit. The closing of this contact cuts the starting magnet again into circuit, thereby picking up the lower electrode and starting the

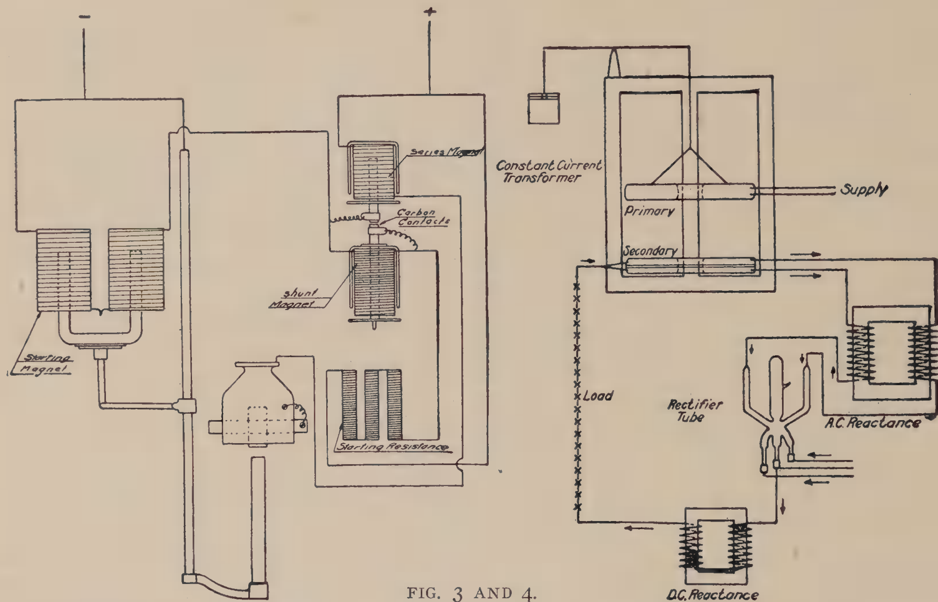


FIG. 3 AND 4.

arc as before, with the correct length of arc for proper operation.

The series magnet is of low resistance and causes a drop of only a volt or two between the terminals of the lamp and arc when the lamp is in operation. The lamp is so designed that only two single adjustments are necessary: the adjustment of the shunt armature to feed the lamp at the proper arc voltage, and the setting of the stop for the lower clutch to determine the proper length of arc.

The switch which has been ordinarily used with series lamp has been omitted as it has become common practice to install an absolute cut-out with each series lamp, thus making a lamp switch unnecessary.

Advantages of the Luminous Arc Lamp.—The luminous arc lamp possesses qualities of such importance, that its introduction undoubtedly means a revolution in street lighting. This lamp is superior to other lamps used for commercial purposes in respect to efficiency, distribution of light, color of light and low maintenance cost. Its principal feature is its high efficiency, which even without its other advantages would undoubtedly soon establish for this lamp an important position in street lighting.

Efficiency.—Readings made with the luminometer show that a luminous lamp consuming 310 watts at the terminals gives the same intensity of illumination at a distance of 309 feet that the 480-watt direct-current series enclosed arc lamp gives at a distance of 275 feet and that the 480-watt alternating-current enclosed series lamp gives at 247 feet.

Distribution.—In the direct-current open-carbon arc the positive (upper) carbon forms a crater of small area which emits over 90 per cent. of the light. The axis of maximum light distribution is at an angle of about 45 degrees with the horizontal, and the intrinsic brilliancy is unduly high. The well-known disadvantages of the open arc are:

1. Poor diffusion resulting in the casting of hard black shadows from nearby objects.

2. Wide variation in illumination due to the wandering of the arc.

3. Intense illumination in the vicinity of the lamp with greatly decreased illumination at the light intersecting point between poles.

The enclosed arc lamp effects considerable improvement in these particulars. Its distribution and diffusion of the light are better because of the longer arc and the blunter ends of the carbon points.

The luminous arc lamp, however, effects still greater improvement by the possession of qualities of distribution and diffusion that render this lamp ideal for street lighting. All the light comes from the arc which is exceedingly long, a feature which gives a nearly horizontal axis of maximum distribution and at the same time eliminates heavy shadows and contrasts. Moreover, the maximum and minimum luminometer readings differ but slightly, for the electrodes offer practically no obstruction to the light and the distribution is not disturbed by the wandering of the arc.

Color.—The color of the luminous arc light is pleasant for street illumination. The light has a spectrum which is practically the same as that of sunlight, and as

white as any artificial light in commercial service today.

Low Maintenance Cost.—The maintenance cost of the luminous arc lamp is very low. The upper electrode is copper and the arc burns at a comparatively low temperature which results in an average life of about 4,500 hours for its edectrode and a practically negligible cost for renewal. The lower electrode has a burning life of 150 to 175 hours, which allows one man to take care of and trim a much greater number of lamps than is possible with open or enclosed carbon arc lamps. This long burning feature and the fact that only one electrode must be renewed gives marked economy in maintenance.

THE SERIES RECTIFIER OUTFIT.

The station end of the series luminous arc rectifier system includes a constant current transformer connected to the alternating-current source, and the series mercury arc rectifier panel with its accessories.

Constant-Current Transformer. — The constant-current transformers used with the rectifier outfit, have the same general appearance and characteristics as those used with the series alternating arc-lighting system.

The primary windings of the transformer (see Fig. 4) are connected to an alternating-current supply of practically any voltage. The secondaries are connected through small reactances to the anodes or alternating-current terminals of the rectifier tube. A tap at the middle of the secondary connects the transformer with one end of the direct-current circuit on which the lamps operate.

The proper adjustment for current in the lighting circuit is obtained by small weights attached to the rocker arms which support the movable coils of the transformer. The transformer will regulate from full load to slightly below one-half load with constant secondary current.

The constant current transformers for outfits of under 50 lights capacity, are air cooled, while the 50-light and larger sizes are oil cooled.

Reactances.—The small reactive coils already referred to, are enclosed in a common case, and protect the secondary from inductive kicks or high-frequency oscillations which may be caused by disturbances on the line circuit.

Another reactive coil is inserted in the direct-current side of the rectifier circuit in series with the lamps, in order to reduce the pulsations of the rectified current.

Rectifier Tube.—The rectifier tube is the means by which the alternating constant current is changed to direct current for the series circuit. It consists of an exhausted glass vessel (Fig. 5), containing one carbon anode or positive terminal in each of the two upper side arms, two mercury starting anodes and the mercury cathode or negative terminals at the bottom of the tube.

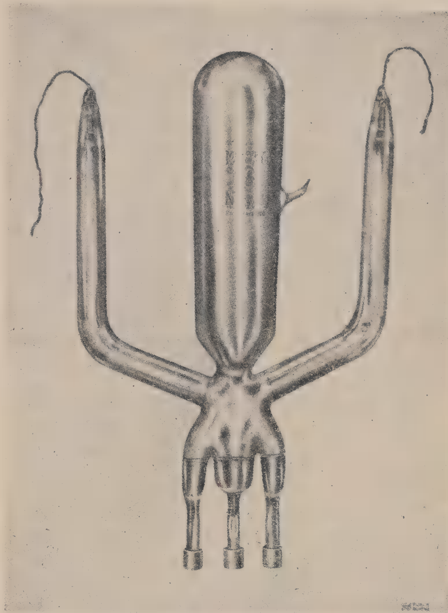


FIG. 5.

The rectifier tube is supported on the panel in a movable wooden holder. The tube is put into operation by shaking it slightly, which causes a flow of mercury between the mercury starting anodes and the mercury cathode, thereby bridging the circuit and permitting a flow of current from the low voltage exciting circuit connected to the starting electrodes. The breaking of this bridge causes the formation of a small arc at the bottom of the tube between the starting anodes and the cathode. With this small arc in operation, the main arc can be established by closing the primary switch of the constant-current transformer, which throws the secondary of the transformer in circuit with the operating anodes of the tube.

With the tube operating at four amperes there is a drop equivalent to about 25 volts or a loss of 100 watts, which is constant at all loads. Under normal operating condition the average life of the tubes on 25, 50 and 75-light circuits is over 400 hours. Reports from commercial installations show that the maximum life reported is over 1,200 hours. Following is a quotation from a paper read by W. S. Barstow before the National Electric Light Association at its convention held at Atlantic City, in June, 1906:

"There have now been in operation in Portland, for several months, over 800 lamps with rectifiers, and the installation is

being rapidly increased as fast as deliveries can be made. The system has proved successful and has fulfilled expectations. Considerable difficulty in the form of static discharges and short life was at first experienced with the tubes. The tubes, which were of small size, were subjected to very rigid requirements on account of the alternating-current pressure of 18,000 volts, a pressure which was very much higher than anything yet attempted with mercury rectifiers. The tubes have now averaged over 650 hours and several have exceeded 730 hours, 500 hours being the economical requirement, and anything above this being in the nature of a gain in the original calculated efficiency of the system."

Capacity.—The standard sets are designed for 12, 25 and 50 lights, although outfits of larger capacity can be furnished if required.

Frequency.—One of the most important advantages in connection with this system is the readiness with which it can be adapted to circuits of any frequency from 25 to 140 cycles. The standard sets are designed for 60 cycles, but outfits have been designed for and are in operation on circuits of 25, 33 and 40 cycles.

Efficiency and Power Factor.—The efficiency of the rectifier sets when operated at full load with rated primary voltage and frequency varies from 85 to 90 per cent. depending upon the capacity of the set. Under the same conditions the power factor varies from 65 to 70 per cent.

Switchboards.—The switchboard consists of a single piece of blue Vermont marble, 62 by 24 by 2 inches, supported on a pipe frame eight feet high. These boards are designed for installation immediately in front of the constant-current transformer and are not a portion of a complete switchboard.

The following equipment is mounted on each board: One mercury rectifier tube, one tube holder, one handle for starting tube, one ammeter in protecting case, two open-circuiting plug switches, one short-circuiting plug switch, two primary plug switches (double-throw switches are furnished with 50 light sets,) one starting switch, one blower motor switch.

Blower.—A blower for cooling the rectifier tubes is furnished with each set. This blower is direct-connected to a small horsepower motor operated from either a single-phase or a three-phase circuit. If several sets are installed, one larger blower with the proper system of distributing the air can be used for cooling all the tubes.

Installation.—The series rectifier system was first introduced about one year ago, and since its introduction, orders have been received for over 80 sets, with a total capacity of 4,500 luminous arc lamps, the largest installation being at Portland, Ore., where a system of 1,200 lights capacity has recently been installed.

THE STANDARDIZATION OF INCANDESCENT GAS MANTLES

By Van Rensselaer Lansingh.

A Paper Read before the American Gas Institute at Chicago, October 18, 1906.

When electricity first began to be a competitor of gas in the field of illumination, there was great fear among the gas interests that gas was to be supplanted by electricity, with the result that gas securities at once fell off in value and it was some time before they recovered. It is not difficult to see why this panic arose. We can take as an average condition that gas at that time sold for $1.25 per thousand cubic feet (which is probably low) and that it gave approximately 16 CP per 5 cubic feet. This made the cost to the consumer per hour ⅝ of a cent for 16 CP. If we assume that the electric lamp of that period consumed 4 watts per candle and that the cost of current was 20 cents per Kw. hour, the cost to the consumer was 1¼ cents per hour for a 16 CP lamp or twice the price of gas. When all the conveniences of electricity were considered as compared with gas, it was seen at once that if improvements in the efficiency of lamps and a reduction of electric rates were possible, electricity would shortly very largely displace the open flame gas burner. This reduction in the rates of electric current and improvements in lamp filaments did occur, but at the same time a new powerful factor came to the aid of the gas industry, namely the Welsbach or mantle burner. At the time, many gas companies feared that the introduction of this burner, consuming from 3½ to 4 cubic feet of gas per hour and giving in the neighborhood of 60 CP would mean a serious reduction in their revenues and bitterly opposed its introduction. As a matter of fact, the mantle burner proved the salvation of the gas industry, as far as lighting was concerned, as the ordinary open flame gas could never hope to compete with electricity with the lowering of rates and the introduction of more efficient lamps. The introduction then of the mantle burner proved to be a most powerful factor in the gas field and opened up new sources of income to the gas company and enabled it not only to meet electric competition but in many cases to overcome it.

Up to perhaps a year ago, the situation had resolved itself as follows: It might be taken on an average that gas was being sold for $1.00 per thousand cubic feet, and that the standard mantle burner, consum-

ing from 3½ to 4 cubic feet, (3½ under laboratory conditions, 4 under actual service) was giving a candle-power of 60 candles. Electricity on the other hand was averaging perhaps 8 cents per Kw. hour, (in many cases more and in many cases less) and the standard lamp throughout the country was 3½ watts per candle. In the large cities the customers were supplied with 3.1 watt lamps but in the smaller places it was not unusual to find 4 watt lamps. Under these circumstances electricity for the same candle-power was about 4½ times as expensive as gas.

Despite this overwhelming advantage for the gas industry, electricity, owing to its numerous advantages, has continued to grow, perhaps even more rapidly than gas and in many cases at the expense of gas. It is not necessary here to enumerate these advantages in detail since they are probably fully as well known to the reader as to the writer.

Attention is called, however, to one or two important advantages of electricity which are often overlooked by the gas man and which the gas engineer could do well to copy as far as possible. One of these is the ability to subdivide the light into any convenient size unit, varying all the way from powerful lamps of 100 candle-power to small miniature lamps of one candle-power or less.

Second: The ability to place these different size units in just the places where they are most needed and not attempt to illuminate a room by flooding all parts with light.

Third: The ability to equip the lamp with glassware which would either direct the rays of light in ways wanted, such as opal, prismatic, etc., or else give diffusion with comparatively small losses by absorption.

During the past year the situation from the electric standpoint has materially altered; there has been, in many cases, a reduction of rates, often of a more sweeping nature than corresponding reductions in gas, but the principal change has been in the introduction of new lamps of higher efficiencies. The first lamp of this nature to appear on the market was the Gem or High Efficiency type, consuming 2½ watts per horizontal candle-power. This was followed by the Tantalum lamp consuming 2 watts per candle-power and the electric industry is looking forward to the introduction of a new type of lamp, the Tungsten, which is promised for the market at 1¼ watts per candle-power. Other types of lamps such as the Osram, Osmium, Zirconium, Kuzel, etc., give promise of even higher efficiencies and it is confidently expected by the electric trade that within two or three years, there will be lamps on the market with an efficiency of perhaps ½ watt per candle or 1-7 of the present 3½ watt standard. Granting, however, that for some time to come, the 1¼ watt lamp will be as high an efficiency as will be attained in commercial practice, we see that the electric man will be able to reduce his current consumption from 3½ to 1¼ watts per candle or a reduction of nearly ⅔ of the present cost. We therefore see that with the introduction of a lamp of this type, gas will be placed in the same position, perhaps not quite as good, as it was when we had only the old type of burner and the old 4 watt incandescent lamp. The cost of electric lighting then will not be greater than 1½ times that of gas and with a possible reduction to equal or even lower cost.

This is the situation to be faced, perhaps not today but very shortly. Even today with lamps of the Tantalum type taking 3 watts per candle we find that electricity has a greater advantage over gas than formerly as the cost is reduced to nearly one half of what it was. Thus if electric lighting has been able to grow at its former cost, it bids fair to grow even more rapidly under these conditions.

This then is the situation as it must be looked at and the question arises, how are we going to meet these conditions? In some cases we find that there has been a union between the gas and electric interests and that gas is pushed largely for cooking and electricity for lighting, but in the great majority of cases the gas and electric companies are separate and each is competing for all the trade it can possibly get. It is therefore necessary to analyze the situation carefully and see what the gas man can do to meet this threatening advance on the part of electricity.

It does not seem at the present, that any great advance can be hoped for in increased efficiency of the present mantle burners for ordinary use. Something has been accomplished along this line through pressure burners but generally this means a mantle of such high intensity and high candle-power that it is necessary to largely offset this added efficiency by the use of dense diffusing globes, so that little or nothing is gained. Moreover the use of such burners is necessarily limited. It seems, therefore, that the best way to meet this threatening competition is by the best use of the present materials available.

Up to this time the gas man has given little or no attention to the correct placing and distributing of lights or to their equipment with the best glassware for the purpose in hand. In other words, the term "Illuminating Engineering" is almost unknown to the gas man, but that the gas industry is awakening to the necessity of more light on the subject is evidenced by the great increase in the demand for such information, and the fact that the Illumi-

nating Engineering Society but recently formed, numbers among its members those representing the largest gas interests of the country. In the transactions of this society the gas man finds the most authoritative data on the correct use of light, and the interest in this subject is one of the growing signs that the gas man will successfully meet electric competition.

One of the latest weapons placed in the hands of the gas engineer is the inverted burner, where the natural distribution of light for ordinary illumination is far superior to the standard upright type. As far as distribution is concerned, it is possible with the inverted burner to generally obtain with ordinary glassware, as good if not better distribution than with the upright burner equipped with the best forms of redirecting and diffusing glassware. There are, of course, many disadvantages today with the inverted burner, chief of which must be reckoned the discoloration of fixtures, and it would seem that the gas engineer has a fruitful field in getting fixture houses to design a line of fixtures which are especially suitable for the inverted type. Even the question of finish is important, as the ordinary brush brass or polished brass fixture tarnishes very quickly with the heat. If on the other hand, finishes such as verde antique or other dark finishes were used on both burner and fixture, the discoloration would show very much less. Of course in many cases such finishes would not be suitable but where they can be used it will do away largely with this serious objection. The attempt to adopt the inverted burner to the present type of fixture is generally unsatisfactory, but it should be an easy matter to design fixtures which will be suitable for the inverted type, so that it will be available in many places where not suitable at present.

One trouble with the inverted burner on the ordinary fixture today is that it concentrates too much light directly underneath, as the fixture is generally hung rather low. If the fixture were properly designed so that it could be placed close to the ceiling and the lights governed by some form of distance lighter, such as the pneumatic and electric lighters which are now on the market, extremely good results could be obtained for lighting different classes of rooms. Further if inverted burners in small sizes should be designed so that two or three units would only consume the same amount of gas as the present unit, we could obtain, when properly placed, a far more uniform or economical method of lighting. Such units could be placed closer to the ceiling than the larger ones where the concentration of heat is an important matter. In other words, it would be possible by the burner companies constructing small burners, either of the upright or inverted type, which can probably be made as efficient as the larger standard sizes, to meet one of the advantages which the electric man has today, namely, the ability of placing smaller units in positions where the illumination is desired.

Another way where it is desired to use the upright form of burner is to make a more careful study of the best forms of burners and glassware such as was given in the paper by the writer before the Western Gas Association in May, 1906. The ordinary opal "Q" globe which has had such a phenomenal run, has been shown to be inefficient and should be replaced by better types. This paper does not admit of a fuller discussion as to how to improve the illumination by the best means available, but as this matter has been covered more or less fully in different technical papers, the writer would refer to the same.

There is one question, however, which has been given altogether too little consideration, namely, the question of supplying the customer not only with the best type of burners, glassware, etc., properly placed, but also with the very best mantles possible. It is not uncommon today to find some of the largest gas companies selling, and in many cases recommending a mantle which retails for from 5 to 10 cents, evidently failing to realize that it is impossible to give the customer the best satisfaction from such a mantle. Most of the electric companies have long ago graduated from such elementary ideas. We find today the large progressive electric companies going so far as to supply their customers, free of charge, with the best lamps obtainable and selected carefully for the voltage at the customer's place of business or residence, and also maintaining expensive organizations to keep these lamps in the best possible condition. By this means many of the complaints which formerly troubled the electric companies have been done away with and they have been in better shape to meet the keen gas competition than would otherwise have been possible. When such a company buys its lamps it buys them on a set of rigid specifications. Thus the lamp company furnishing the lamps must guarantee the initial candle-power of the lamps; must guarantee that it shall not vary more than one or two volts either side of the rated voltage of the lamp; must guarantee that its life will be so many hundred hours before the candle-power has decreased to 80 per cent of its initial candle-power; must guarantee that all lamps be free from any mechanical imperfections, as well as fulfilling other requirements; and the question naturally arises, should it not be the policy of the up-to-date gas company

to follow along the same lines? Why should not such a company buy its mantles on a set of rigid specifications with a guarantee from the company from which it purchases its mantles, that all mantles so purchased should live up to these specifications and with a penalty attached for any which fall below the standard? If this were done, it would probably do more to make satisfied gas customers than anything else which is at present available.

In order to find out whether there was any material difference between a cheap mantle and a high grade mantle, the writer has had a series of tests made at the Electrical Testing Laboratories of New York, on 40 mantles, 10 being of the highest grade obtainable, 10 of a medium grade, 10 of a still cheaper grade and finally 10 of a very cheap grade.

These four mantles are designed in the following test as Nos. 1, 2, 3, 4. No. 1 is an asbestos tied cap mantle supported by a ring and side rod covered with a magnesia tube, selling to the trade for 20 cents. No. 2 is an asbestos tied, single side-rod supported mantle, the cap form of which wholesales for 13⅓ cents. This one was selected as it is often used with a center support. The price of the No. 2 is given in the cap form as the other three are of that type and this gives a better insight into the relative values entering into the mantles themselves. No. 3 is an asbestos tied, double rod supported cap mantle wholesaling for 8⅔ cents. No. 4 is an asbestos tied, double rod supported cap mantle wholesaling for 6⅔ cents. The forty lamps were all burned on gas obtained directly from the mains of the New York Gas Company, New York City, at pressures varying from 1.4 to 2.0 inches of water. The lamps were mounted on two pipes which were drilled and tapped to receive the nipples. These pipes were fastened rigidly to the floor and wall of a large basement room, nearby machinery producing a slight vibration at certain periods of the day. The lamps were mounted 10 inches apart, 20 upon one pipe and 20 upon the other, being in rotation, No. 1, 2, 3, 4, No. 1, 2, 3, 4, etc.

It had been intended to photometer the lamps at intervals throughout the tests while in position upon these racks. As no pressure regulators were available, results obtained would have been affected by pressure variations in the mains. Therefore it was found simplest to remove the galleries to a nearby photometer room and there carry out the photometric tests. This was done, in every case the lamp being supplied with gas at a pressure of one and one-half inches of water. Of course such removal of mantles and galleries is decidedly objectionable and the value of these tests is not so much from the standpoint of absolute values as it is to point the way for a more systematic and rigid investigation. However, as all mantles were tested alike we are able to draw at least comparative results. Photometric tests were made at the start, at 96 hours, 194 hours and 555 hours. The 194 hour measurements are not comparable with the others inasmuch as the lamps were not removed from the rack and therefore there was a difference due to variation in pressure. These readings are therefore omitted in the report.

Among many of the mantles minute breaks were observed during the first hour of burning, in some cases immediately after the mantles were burned off. The rather rapid increase in the number of such breaks made it apparent early in the test that the comparison of values would have to be based upon breakages more largely than upon candle-power deterioration. In this case time did not permit of the complete test upon any mantles which might be substituted for those which were broken among the first group placed upon test, consequently it was decided to run all mantles for as many hours as possible and note the results. The breakage of ten chimneys at 364 hours however, (this breakage occurring when the gas was turned off the lamps) necessitated the removal from test of a corresponding number of mantles, no replacement chimneys being at hand. Those which were in the worst condition were accordingly removed irrespective of the brand. At this time also the 5 other mantles which were unfit for further service were removed from test. All other lamps burned for at least 555 hours.

It will be seen from the above description that these tests are not at all satisfactory from the standpoint of deterioration. They do show, however, a great deal relative to the mechanical strength of the

	Initial			96 Hours			555 Hours		
No.	C. P.	Cu. Ft.	C. P. per Cu. Ft.	C. P.	Cu. Ft.	C. P. per Cu. Ft.	C. P.	Cu. Ft.	C. P. per Cu. Ft.
1	93.0	4.55	20.5	75.5	4.2	18.0	63.0	4.07	15.6
2	64.4	4.25	15.4	67.0	4.10	16.4	47.2	4.0	11.9
3	73.3	4.18	17.4	66.3	4.26	15.6	45.5	4.1	11.3
4	88.0	4.52	19.5	64.6	4.18	15.5	47.0	4.3	10.9

TABLE I.

mantles. Thus at the end of 555 hours, there were two mantles out of ten of the No. 1 and two mantles out of ten of the No. 2 which were in perfect condition, while none of numbers 3 and 4 were in good condition.

The detailed results of how the different mantles failed are not given here, inasmuch as this paper is meant to be suggestive rather than a complete study of the situation and only the general results are stated.

The accompanying table shows the deterioration of the different types of mantles, the values representing the mean of the different mantles tested:

These results are shown graphically on Plate 1.

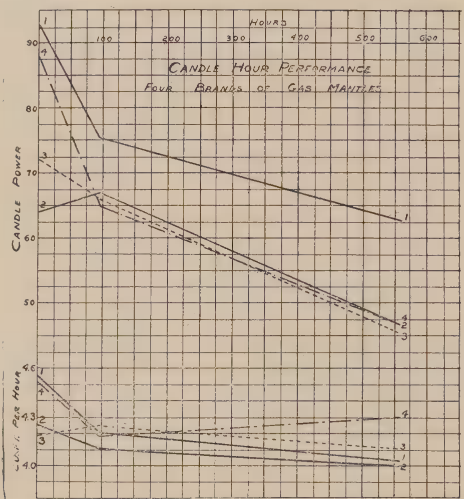


PLATE I.

Regarding the test on type 1, it should be noticed that the initial candle-power falls off very rapidly during the first 100 hours after which the deterioration is very much more gradual. The figures given are the mean of the six mantles which lasted throughout the test of 555 hours. On examining the ten mantles which lasted for 96 hours we find that there is even a slightly greater drop during this time so that this test shows rather conclusively that there is a decided tendency to fall off rapidly in candle-power during the first 100 hours of life.

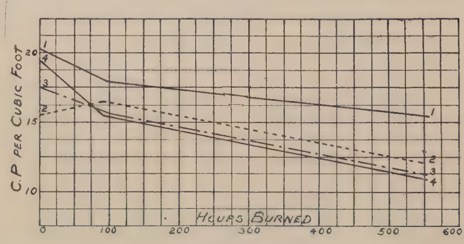


PLATE II.

Type 2 shows that there is a slight increase in the candle-power up to 96 hours. Only 5 mantles were included in these figures. In the original report if we examine the complete test for ten mantles we find that instead of a slight increase at the end of 96 hours there is a decrease, so that in all probabilty a complete series of tests would show that the deterioration of this mantle was practically uniform, the same as is shown by No. 3.

No. 4 exhibits the same characteristics as No. 1, namely a very rapid falling off in initial candle-power and a more gradual decrease afterward. The rapid decrease in No. 4, however, is greater than in No. 1.

Plate 2 shows the characteristics of these four mantles with reference to their efficiency or the candle-power per cubic foot of gas at different periods of their lives. This plate shows as do the other tests that mantle No. 1 is of much higher efficiency than the others throughout its entire life and that No. 4, starting off with a high initial candle-power falls below the others after less than 100 hours burning. No. 2 although starting lower in candle-power than any of the other mantles is superior with the exception of No. 1 throughout most of its life. Plate 2 gives perhaps as good an idea as is possible to obtain graphically of the relative values of these mantles and shows that their values are, roughly speaking, in accordance with their costs. It is to be noted that there is on the whole comparatively little difference between No. 2 and No. 3, as far as the light giving quality of the mantles is concerned. A breakage test, however, would show that No. 2 is superior to either No. 3 or No. 4 and No. 3 is better than No. 4. We thus see that the value of a mantle depends not only on its candle-power hour performance but also on its ability to withstand the usage which it is ordinarily subjected to.

It will be noticed that No. 1 deteriorated in candle-power per cubic feet of gas in the 555 hours of test about 24% and Nos. 2 and 3 about the same, showing that these three mantles deteriorated about equally. No. 4 however, representing the cheapest mantle tested, showed a deterioration of no less than 46%. The net low efficiency throughout the life of the No. 4 mantle is largely explained by the fact that the skirts of these mantles at the cap wore off at the bottom until no longer over-lapping the cap. In some part the wearing away of the skirt of the mantle may be explained by the fact that after these mantles were burned off, in most cases they were no longer cylindrical at the bottom, the distortion causing them to rub against the cap. One thing to be carefully noted from these tests is that some times the cheapest mantles on the market have a high initial

candle-power but that they very rapidly fall off in value. This class of mantle is largely handled by peddlers and even by some of the gas companies in their endeavor to increase the sale of gas. The practice of putting out such mantles as these is decidedly objectionable inasmuch as the customer, starting off with a mantle of high initial candle-power is apt to blame the gas company for the very rapid and marked decrease in light which leads to dissatisfaction and opens up an opportunity for the electric company.

As before stated, the results of these tests are unsatisfactory. The question as to the value of mantles is a very broad and comprehensive one and is not or should not be determined by any one individual. The question being, in the opinion of the writer, of such vital interest to the gas industry of this country, he would suggest that it is fitting for the new American Gas Institute, representing as it does almost the entire gas industry of the country, to appoint a committee which would thoroughly investigate the subject, the proper funds for the same being supplied by the Institute. Complete tests would be too expensive for one individual or company to carry on, over 100,000 cubic feet of gas being used in the tests given in this paper, while if shared equally by those who are interested, namely, by the members of the Institute the pro rata cost would be small. Further, if such tests were conducted individually they would lack the authority which would be given them by being conducted by the Institute. A similar committee was appointed some years ago by the National Electric Light Association to investigate different forms of illuminants, especially arc lights for street lighting and the results of those tests were of great benefit to the members of the Association and the industry as a whole and remain today the standard in this country. Would it not be possible for the Gas Institute to employ competent engineers to carry on such tests so that the whole gas industry would reap the benefits? At the same time this would remove all questions of commercial bias. It might even be possible to establish a permanent laboratory under the auspices of the Gas Institute where mantles selected from any given purchase could be sent and tested, such a laboratory to fulfill in the gas field the same place as the Electrical Testing Laboratories fulfill today in the electric field. Such a committee could undertake to standardize a set of tests or specifications, which mantles of a given price or quality should undergo. The writer would tentatively suggest that such a committee consider the following:

(1) The initial candle-power on a standard gas, at a given pressure and with a given consumption, should be not less than a stated amount.

(2) The life of a mantle should be a stated number of hours before it falls to a given percentage of its initial candle-power.

(3) A mantle should undergo a jar test to prove its mechanical strength. A standard jar test could be easily arranged so that all mantles would be subject equally to such vibrations.

(4) The method of support for mantles should be stated. Tests could probably be conducted to determine the best method of support.

(5) The weaves of mantles could be specified. Complete tests would undoubtedly show which weaves are best adapted for different conditions.

(6) The amount of shrinkage during the useful life of a mantle should be distinctly specified, in order to prevent binding at the skirt, etc., with consequent breakage.

(7) The question of shape both before and after burning off should be carefully considered, as many mantles fail from such causes.

(8) The question of color should be carefully considered and specifications should state the color required, as different colored light is required for different purposes.

If rigid specifications with a penalty clause were adopted by gas companies and the Institute or some standard laboratory could conduct such tests, it would be possible to select, say, one mantle at random out of each thousand with the understanding that such a mantle represents the thousand. If such a mantle falls below requirements the entire lot would be penalized.

If the large gas companies could buy mantles on some such scheme of specifications and see to it as far as possible, that the customers were supplied with such mantles (which of course the gas company could guarantee) the writer believes that it would do as much toward popularizing the use of gas as any other method now available and he respectfully suggests that the American Gas Institute appoint a committee to further investigate the situation.

NOTES ON STREET LIGHTING

By J. I. Mange

Manager Watertown Light and Power Co., Watertown, N. Y.

A special and very important department of lighting has to do with streets and other outdoor spaces. It involves not a few unusual difficulties, for there is unlimited space to deal with as well as an indefinite variety of natural and artificial obstructions, and, save in narrow streets

bordered by high buildings, one gains little or nothing from the diffusion that is so important a factor in interior lighting; and in many instances the streets are so thickly shaded by trees that the problem of adequate lighting is very difficult, and one for which local data are necessary for its solution, if it is to be done properly. The amount and distribution of streets and the needs and distribution of the population are the controlling factors in the matter and obviously these vary greatly from place to place.

It is interesting to note that it is now about twenty-five years since the electric arc was first applied to street lighting, and it has proven itself to be really the only source of light profitable to consider.

The incandescent lamp is by no means to be thought unfit for service, as many of them are now doing admirable work in small towns, in suburbs of cities and in many blind alleys and courts where the expense of an arc lamp is unnecessary. However, at the same total cost, the arc lamp gives a considerably higher average illumination, and experience shows that on the whole arcs which have to be inspected at frequent intervals for the purpose of trimming are kept nearer their point of maximum efficiency than incandescents.

INCANDESCENT LAMPS.

In streets where shade trees hang very low and the foliage is very heavy, arc lamps are at a great disadvantage. Here, as well as in many other places where there is no real need of a brilliant light, the incandescent is capable of doing good service at a moderate cost. Economy also sometimes dictates caution in the expenditure for street lighting, and in most cases recourse can be had to the incandescent.

The incandescent lamp is usually fifty, seventy-five or one hundred candle-power when operated in series with the arc lamps, and sixteen, twenty-five or thirty-two candle-power when worked in series upon an alternating current circuit of one thousand or two thousand volts, taking two or four amperes. It should be noted, however, that lamps so operated are costly in the matter of renewals and difficult to operate satisfactorily.

In view of the rapid deterioration of the brilliancy of the incandescent, it is not wise to space them over one hundred and twenty feet apart for good service; although in heavily shaded streets if one hundred candle-power lamps are used and placed on alternate sides of the street, the space between consecutive lights may be three hundred feet and still produce a fairly well lighted thoroughfare.

This makes the first cost of installation rather high, and therefore the cost per year to the city is higher, relatively, than the arc lamp. For a fifty candle-power lamp the average price is twenty-five to thirty dollars per year.

GAS LAMPS.

Gas lamps have been used with considerable success much in the same manner as incandescent electric lamps are used. The old-style open-flame lamp was a very wasteful one, burning eight or twelve cubic feet of gas per hour with little illumination.

With the advent of the incandescent mantle burner, such as sold by the American Gas Light Company, of New York, gas lamps became quite popular and are used now to some extent. These lamps are economical, burning only three and one-half to four cubic feet per hour. The average price for such service is about thirty dollars per year. They are, however, open to the objection that they must be individually lighted and extinguished. The rapid shrinking of the mantles with a diminution of candle-power is another bad feature.

Gasoline lamps with individual tanks have been put on the market, but to the writer's knowledge no success has been attained.

ARC LAMPS.

For about ten years the only available arc lamp was the open full arc of two thousand nominal candle-power. These lamps operated at a high amperage, approximately ten amperes, with a low arc voltage, producing a powerful white glaring light near the lamp, and when fitted with clear globes offered a method of illumination which impressed and satisfied the general public. who became accustomed to it and thought the more glaring the light, the better the lamp and system; while in fact the glare is the most serious objection to the open arc, because of the fact that in the presence of lights of great brilliancy the eye contracts and does not recover promptly enough in passing beyond the glare to get the full value of the relatively feeble light at a distance from the lamp.

To meet the demand for cheaper light the "Half Arc" of twelve hundred nominal candle-power was introduced. This, however, had the same objectionable features as the full arc, except the glare in the vicinity of the pole was less aggravating.

INCLOSED ARC.

The inclosed arc lamp is by far superior to the open arc. In it we have a long arc burning in an inclosed globe in which the air is practically free from oxygen. Although most of the light comes from the crater, still a greater percentage is emitted directly by the arc itself, owing to its length.

A large portion of the crater's area is

visible over a wider vertical angle and the crater is not so concave as in the open arc; hence less concentration and better distribution of light. The principal variation in the light of an inclosed lamp is caused by the travel of the arc over the flat carbon ends.

This variation can be greatly reduced by the use of an opal inclosing globe, which becomes luminous all over and obliterates the shadows which would otherwise be cast by the side rods and lower carbons. Even if we used a clear inclosing globe, the shadows are not so strong in contrast as those of the open arc.

DISTRIBUTION OF LIGHTS.

The number of lamps per mile is governed, to a great extent, by established location, distance between cross streets, length of blocks, and other local conditions. Nevertheless, the greater economy and superior illuminating value of small units is well worthy of consideration.

While with a constant arc voltage the candle-power of an arc lamp increases in proportion somewhat more rapidly than the watts, the lighting distance increases only as the square root of the candle-power. It is therefore more economical to work with the lower efficiency arc at a short distance than with the higher efficiency arc at a long distance.

There are four standard units of the alternating-current inclosed lamp, viz., 485 (7.5 amperes), 425 (6.6 amperes), 350 (5.4 amperes) and 285 (4.4 amperes) watts per lamp. The distance to which these units will project a given illumination is 247, 227, 197 and 178 feet, respectively, with a corresponding watt consumption per mile of 5,180, 4,940, 4,690 and 4,235, thus showing, in favor of the 4.4 ampere lamp, a saving of 945 watts per mile over the 7.5 ampere lamp for the same illumination midway between lamps and with the additional advantage of confining their more brightly illuminated areas along the street.

By maintaining 5,180 watts we can run slightly over eighteen 285 watt lamps per mile; but while the small unit will light a greater distance per watt, the advantage is somewhat offset by the increased initial cost and maintenance per mile for the additional small units required.

LUMINOUS ARC LAMPS.

There has been developed in the last year a lamp that is a wonderful improvement over all type of lamps; it is the luminous arc lamp made by the General Electric Company. It is a direct-current lamp of four amperes operated by either the Brush machine or Rectifier Tubes. This lamp operates with about three hundred to three hundred and twenty watts at the terminals and gives an effective illumination of about 30 per cent. greater than the inclosed arc, either series, direct or series-alternating. Tests have shown that the direct-current arc with 480 watts at the terminals gives a certain illumination at 257 feet, the series-alternating inclosed arc with the same energy gives the same illumination at 247 feet, while the luminous arc gives the same intensity at a distance of 325 feet. It is absolutely steady and casts no shadow. It has a life of 180 hours as against 80 hours for the other lamps and requires only one electrode at each trimming.

Many cities which are installing new systems have chosen the luminous arc lamps and the writer is installing them in Watertown, N. Y.

GLOBES FOR INCLOSED ARCS.

The choice of globes for the inclosed arc lamps is a matter of some importance. Tests show that the opal inclosing and clear outer globe is a combination that gives the best results, the explanation being that the strongest light throws from the arc at an angle of 35 to 40 degrees below the horizontal, while it brilliantly illuminates the lower portion of the globe which diffuses the light upwardly and compensates for the loss by absorption through the useful angles.

A 6.6 ampere series-alternating lamp has, under test, projected light through various combinations of globes as follows: Opal inclosing and clear outer, 227 feet; clear inclosing and clear outer, 207.9 feet; clear inclosing and opal outer, 192.4 feet; opal inclosing and opal outer, 188.5 feet.

To advise in the abstract concerning the hanging of arc lamps is almost impossible, as local conditions practically force the use of one or the other of the various ways. Most arms and cross suspension are generally used where the wires are overhead.

Pole top fixtures are used occasionally in public squares, but are not very desirable where any other form of support can be used.

Where the system is underground, ornamental poles are desirable. The distance above the ground arc lamps should be hung must be determined for each individual lamp. For open arcs the distance should be about thirty feet; for series direct-current inclosed lamps, twenty-two feet; for series-alternating inclosed lamps, eighteen to twenty feet; for the luminous arc, about thirty feet. However, in heavily shaded streets it has been found desirable to hang lamps as low as twelve feet from the ground.

Commercial Engineering of Illumination

SOMETHING ABOUT GAS ARC LAMPS

By Bert Mason.

A few days ago when the writer was requested to prepare a paper for this meeting the subject suggested was, "Something About Gas Arc Light." So, with your kind permission and indulgence, it will give me great pleasure to have the honor of addressing you on this subject.

In the first place, let us consider what a gas arc is worth to a gas company as a revenue producer. Most gas men of today will all agree that 24,000 cubic feet per annum is a very conservative estimate for 4-burner arc lights. However, it is the opinion of the writer that 36,000 cubic feet is a modest estimate on the consumption of a 4-burner arc, if sold by a salesman of gas, instead of being placed on the market by a salesman of appliances. The salesman of gas will, in all cases, endeavor to put the arc lights in the market where they will work the greatest number of hours. On the other hand, the salesman of appliances will endeavor to sell arc lights any place where they can be hung, regardless of what they would burn. The difference between the salesman of gas and gas appliance salesman is obvious, and the average estimated consumption of arc lights may be greatly increased or lowered, according to the salesman and plan you have of placing the arc lights on the market. In order to obtain a first-class salesman, pay him always according to the quality of his business, as well as the quantity.

To save time, and to avoid an argument as to the average estimated consumption of gas arc lights, let us concede it to be 24,000 cubic feet per annum. Now, compare the gas arcs with the gas range at an average estimated consumption of 16,000 cubic feet per annum, which is considered a very liberal estimate by the gas men from coast to coast. There, in plain facts and figures, we have the gas arc leading the range by 8,000 cubic feet. Inasmuch as gas companies derive the bulk of their revenue from gas sold for the purpose of lighting and cooking, it simply means the gas companies must depend principally on gas arcs and gas ranges. Any appliance that will consume gas and give the consumer satisfaction has its place in the sales end of the gas business, but, after all, only incidentally to the chief revenue producers, namely, the gas arc and the gas range. When you sell a consumer one range, that is all he really has use for, and, in fact, all he needs. It is just the reverse with the gas arc. When you sell a gas arc, if, indeed, you but sell one, it is only a matter of a very short time when the consumer will discover he really needs from one to several more gas arcs. So to be as brief as possible, the writer will say that, as a result of his experience in many different states, the average of three arc lights to a consumer is not at all excessive. Now, then, we have three arc lights to a consumer as against one range, or 72,000 cubic feet against 16,000 cubic feet, according to the universally acknowledged estimation of these appliances. Some gas men will say they sell ten ranges to one arc, and, if so, they would be deserving of great credit for the gas range sales; but the same couldn't be said as to the output of their gas arcs. There is not a city of 75,000 population or over but can make their gas arc light sales equal that of their ranges; and as the cities increase in population so should the sales of gas arc lights increase in proportion to the sales of gas ranges, at least three to one, including residence arcs. Residence gas arcs for residence use should average 10,000 cubic feet per annum; but suppose they only average 5,000 cubic feet per annum, and from one to three could be installed in every residence, would not that be a great increase in the residence district? Every house has room for a gas range, and always has room for one or more residence arc lights. Not so with every house as regards to the gas range, because there are several houses that actually do not have room for a gas range, but in every case have room for a residence arc light. There is a great deal more that could be said in favor of the gas arc as a revenue producer; but let us rest that question with the above remarks and proceed to the next phase of the subject.

Having briefly considered some of the reasons why we should sell the arc lights, the next question is, "How shall we sell them?" At the very start off secure the best "salesman of gas" that money will obtain, for it is better to have an expert in this line of work for two months at a high salary than to employ inexperienced men on a small salary for a year. Carefully consider and study the local situation, especially with reference to such competition as there may be, taking great care not to fall into the common error of overestimating the competition. After the above consideration it will be possible to outline a systematic plan to sell gas arc lights that will give a large and certain increase in gas sales. No matter how clear a field there may be regarding competition at present, always remember to regulate the methods of doing business with the plain

fact in view that we are on the market to sell and increase the sale of gas as a permanent institution. The public of today must be catered to. After an increase in gas sales has been obtained, there is no other business in the world that will require any more nursing and cultivating to retain it. Stay right with it all the time. The increase in gas sales will depend largely on the success met with in holding that which has already been obtained. Whenever competition is light enough to place appliances on the market without losing money, it is but fair to do so, providing the margin of profit is not progressively increased, until a bad obstacle is placed in front of the main feature to be accomplished, that of selling gas. There are very few people who would buy a dozen gas arcs at $12 each, as against many people who would buy a dozen at $8 each. The cost of equipment often stands in the way of a very fine piece of gas business when the gas company insists on making quite a margin of profit on appliances. This is not as it should be. Cut out the profit on appliances. Sell them at what they cost you installed, and increase your output of gas sales that much. If it is thought wise to make a profit on appliances, why wouldn't it be better to make that profit on miscellaneous appliances, which ordinarily consume very little gas, and then keep the cost of the gas arc and gas range as low as possible? It would be out of the question to outline a method of procedure which would be applicable to all conditions, but one interesting case in point will be cited.

A commercial department consisting of 14 men, located in the State of Ohio, competing with natural gas at 45 cents per 1,000 cubic feet, as against 95 cents per 1,000 cubic feet for artificial gas, in a period of 90 days installed 1,400 arc lights, 800 of these being natural gas and electric displacements and the balance increased consumption. To accomplish such a wonderful result arc lights were installed on the following basis: Consumers would sign a contract to pay a minimum charge of $1.50 per month for each arc light installed. this amount to apply on their gas bill. In addition to the above charge, the consumer would pay 25 cents per month per arc light for maintenance, and the entire contract would be signed for a period of three years. Simplified, the above plan means the gas company loaned the consumers as many gas arcs as they could use for a period of three years, which consumed not less than $1.50 worth of gas per arc light every calendar month during the period of the contract. At the end of three years, instead of renewing these contracts, it will be a very easy matter to sell most of these arc lights as second-hand, for $5 each, just where they are hung. The main feature will be, however, for the gas company to give perfect service in every respect during the period of the above-mentioned contract, and then at the end of three years the consumers will be glad of an opportunity to purchase the arc lights and burn what they like without being tied to a contract at all. Again, some of the above-mentioned arcs were sold on a one-year contract at what they cost, the gas company installed, provided the consumer would agree to burn artificial gas for a period of one year. You must form your own conclusions as to whether such methods were wise in the natural gas country, and in summing up the situation, do not overlook the increased revenue made for the gas company by this mthod of installing arc lights.

Another good plan for installing gas arc lights is that of renting them for $5 per year in advance, including maintenance. At the end of the year the consumers can lease the arc for another year at the same figure, or they can purchase and own the arc by paying $5, the gas company crediting $2 of the $5 paid in advance to the maintenance and the balance of $3 for the rental of the arc. If the consumer decides to buy at the end of the first year, the company will have received $8 for its arc, according to these figures submitted to you. If, on the other hand, the consumer decides to lease for another year, you have received $6 for the arc light and $4 for the two years' maintenance. This money being paid in advance, at the end of the second year we can afford to sell the arcs for $4 to the consumer, and then will have received $10 for the arc and $4 for two years' maintenance, which gives a total of $14 per arc light, including two years' maintenance. Out of the total of $14 received on the above plan, credit $6 to the maintenance and still you have a balance of $8 to the credit of the sale of the arc light. The cost of maintaining arc lights differs considerably for many reasons, a few of which might be considered.

First, the territory may not average two arc lights to a consumer, which will have a tendency to make the maintenance expensive on account of the ground you have to cover. That can be overcome by forcing your gas arcs to make a larger average per consumer.

The best manner in which to make the maintenance expensive is to engage cheap and incompetent help to take care of arc lights. The men in charge of a gas arc maintenance route can very easily make or waste his day's pay by a little carelessness and lack of good judgment. This sort of man would not have to go far before the cost of mantles would cause the maintenance to be a mighty expensive proposition.

Why wouldn't it be good policy to pay the maintenance man a fair day's wages, and, in addition to that, a suitable bonus for perfect work performed, according to the satisfaction of the consumer? Pay the men the bonus on the first of every quarter. This length of time wouldn't be long enough to cause the man to lose heart in his efforts; and, on the other hand, would be a good stimulant to retain first-class, permanent men, such men, in fact, as gas companies must engage to perform the duties in one of the most important departments connected with the whole gas industry today.

It is only the man that has personally mixed with the consumers who thoroughly understands the great necessity of a perfect working maintenance department. When so much depends upon it, why not study the question constantly, watching every opportunity to better the service and always make it a little more perfect? On the bonus payment plan, the maintenance man should be given credit marks for perfect work accomplished with the least material used. In the event of complaints reported, the man should have marks deducted from his credit, according to the nature of the complaint received. Likewise the men should receive their ratio of the bonus according to the least material used. Cause considerable bookkeeping? Oh, yes; some. However, a mere bagatelle when you consider the object and the result to be accomplished thereby. Passing now to the next natural division, what shall we say to cause the consumer to buy arc lights? Say almost anything you think the consumers would want you to say, and agree with them in all their troubles. Never approach a man directly with the suggestion to increase his gas bill. That above anything else in the world is repulsive to most prospective consumers. They will increase many other expenses willingly, but when it comes to asking them directly to buy more gas they are ready to annihilate you. Consequently the intelligent gas salesman will endeavor to sell his gas to a certain extent in disguise. For example, he will point out many instances where expenses can be cut, in which a business man is spending his money uselessly and absolutely without returns. Then turn and show him where this money that has been wasted can be applied with results which must be far ahead of the manner in which he has been operating. It will be very necessary to make no mistakes, to understand the proposition thoroughly and to present it in a shrewd, calculating and convincing manner. Always be able to prove and stand behind any statements you may make to a consumer. Again, use your very best endeavors to so word your statements that they will be perfectly clear. Never try to sell a man gas by getting him mystified, for invariably when such consumers become perfectly clear on the matter they will say you misrepresented the proposition. Talk illumination for advertising and gas arcs for illumination. There is nothing to beat that argument with the inside and outside gas arcs. These are articles with which a consumer can be served with considerably more of the best kind of advertising for the least money, just when and where they need it, than with anything else on the market. In such advertising they are not compelled to gamble on results, but they can observe to their entire satisfaction great, big returns for the investment.

The objection of the heat in gas arcs, as against that of electric lights, can be largely overcome when you show the consumer that he can purchase gas for lighting for so much less than electric lighting, that he can pay for the use of fans during the hot months and still have a good sum of money left to his credit which he would not have if he burned electric lights. The gas company can afford to use liberal consideration toward its chief competitor, the electric company. There is a whole lot of business in the way of lighting and power that the gas company does not want and is not entitled to. The wise manager of an electric company knows perfectly well where the line is and should confine his company's efforts in soliciting business to that class of work, which he is better able to serve the public.

Today the electric companies are in no position to compete with gas companies in serving straight illumination or window lighting.

The famous great, white light, more commonly known as the outside gas arc, has made window lighting the greatest, cheapest and best proposition which a merchant can indulge in today. They not only light his windows in the best possible manner, but light the whole front of his store and street at the same time, for the one cost. If the outside arc is such a grand proposition why don't more of the merchants use that instead of electricity? Simply because the supply of first-class retail commercial gas salesmen is very limited. Consequently the gas company has not been able to present the subject of outside window lighting as it should be to the merchants in most cities, and have very wisely refrained from sending out inexperienced men who make a miserable failure and only weary the business men.

Great caution must be exercised regarding the kind of men you intrust your business territory to, but most any kind of a house-to-house peddler can make a gas range salesman. It would be, indeed, an injustice to the outside gas arc for window

lighting and novelty advertising to rest the subject without stating something of the virtues as referred to.

With the outside gas arcs equipped with an alabaster globe, installed properly on the outside and in front of the windows, the merchant will receive the following benefits: First, more actual candle-power of light to the gas arc lamp by 200 per cent in proportion to the number of electric lights installed in any windows. Second, receiving the benefit of all the light he is paying for, situated where it will serve a double purpose, that of lighting his windows perfectly without having to hide it, and the further effect of lighting the street and store in front.

This is not true with the hidden electric light, constructed so as to throw the light in the window. It necessarily takes so much from the outside. You can prove this statement by looking along the side of the street you are standing upon, and a few doors from where you are it will be difficult for you to determine where there is a lighted window in a block. With the outside gas arc you know there is a well-lighted window from the fact that you can see it several blocks away. There are a few narrow-minded merchants who object to the outside arc because they claim they do not want to light the city. Don't waste time with them. Leave them to see their mistake, and when the outside arcs are started such people will soon fall in line.

Other excellent places to install gas arcs are on the second and third stories of buildings, just outside of the windows, where they can be easily trimmed from the window sill. Either white or colored globes can be used for this class of work, making a big hit as novelty advertising. There is located in this city, just across the street from the gas office, a French restaurant, on the second floor of which are installed 4 outside gas arcs with colored globes. The proprietor claims those arcs have attracted more people, to look up first, and then go up, than any other kind of advertising he could have purchased.

Last of all, let us consider the trial proposition. Is it wise to install gas arcs on trial? Yes; if you are careful. Thoroughly understand your prospective deals. Make a perfectly clear statement with reference to what you are sure your light will do in the place where it is to work, then the maximum cost per hour for burning; follow up with tact, energy and enthusiasm, and, above all, with perfect confidence in the successful closing of your trial orders. A gas salesman with a fair knowledge of the business, observing the above suggestions, can stick 95 per cent, of all the arc lights he will install on trial. The gentlemen soliciting in this city have installed about 150 outside gas arcs since last March mostly on trial. Records show only 3 returns. Two of this number could not be successfully closed because one gentleman claimed he received light enough from the 3 outside arc lights which his next-door neighbor, a druggist, who had recently purchased and since paid for under trial plan. The remaining arc was taken down on account of lack of room to use a screen door, but will be rehung in the fall.

As far back as most of us can remember, a striped pole has advertised the fact that there was a barber shop wherever you could see such a pole. It is not only a local emblem for a barber shop, but a national and even international emblem. Very good for daylight use and absolutely necessary. However, when daylight ceases, the value of the barber's striped pole has diminished to the extent of advertising only directly in front of his shop. Ordinarily, a barber's best and busiest hours are the hours between dusk and closing time. Instead of losing their "ad," entirely just when they need it most, as they do with the striped pole, what would it mean to barber shops, and, incidentally the gas companies, to patent and incorporate a simple scheme something as follows: Have outside gas arc globes made in red, white and blue stripes to be used for barber shops only, exclusively upon gas arcs. Have we a right to presume barbers would take kindly to this proposition? It would appear so from the fact that we are living today in an advertising age; then the absolute necessity of such an "ad," for the barber shop; and, last of all, the phenomenally low cost of running such an "ad." in consideration for what results the barbers would receive. Of course it doesn't cost anything to use the striped pole, neither will the pole work after dusk. If the barbers need an emblem sign in the daytime, they have double necessity for an emblem light at night. The same subject could be carried further even to the drug stores by giving them an emblem light in the form of a round, white globe with a red cross. If the gas companies would get together and start this movement all over the country simultaneously, advertising the scheme liberally, inside of six months a large, round, striped globe would be known as a barber shop at night for any distance, just as much as a striped pole denotes the same fact by daytime at present.

Review of the Technical Press

AMERICAN ITEMS

Preliminary Measurements on Temperature, and Selective Radiation of Incandescent Lamps.

By C. W. Waidner and G. K. Burgess; National Bureau of Standards, Washington, D. C.

The high efficiency attained in some recent metal filament lamps raises the question whether this is to be attributed to selective radiation or to a higher working temperature of the filament, or to both. In this region of high temperatures almost no data are available bearing on this question, and we have, therefore, thought it worth while to communicate some preliminary results obtained with filaments of carbon, tantalum and tungsten.

TEMPERATURE MEASUREMENTS.

The filament, *F*, of the lamp under observation is mounted in front of the carbon ribbon, *C*, which is itself within an evacuated globe, in such a way that by means of the lenses *O* and *E* the filament is seen superimposed on the carbon ribbon, *C*. This ribbon may be heated electrically to any desired temperature, which is measured by means of the Holborn-Kurlbaum optical pyrometer, the principle of which is briefly as follows: The current in the pyrometer lamp, *L*, is adjusted until the filament is of the same brightness as the incandescent body under observation. From a previous calibration by comparison with thermo-couples and a black body source, the relation between the current in the filament and its equivalent black body temperature is known.

An observation at one temperature consists in setting the two filaments, *F* and *L*, to the same brightness as *C*, and measuring the currents in *F* and *L*. The temperatures of *C* and of *F* are then known from the calibration of *L*. From a series of such measurements at different temperatures the temperature current curve for the filament *F* may be drawn.

Temperature Scale.—The lamp *L* being calibrated by comparison with a black body, when sighted on another incandescent body, reads not its true temperature, but something lower, by an amount depending on the emissive power of the body. By the term *"black body temperature"* is, therefore, meant the temperature at which a black body would send out radiation of the same intensity as that from the object observed for a given wave length. A body at a given temperature will in general have a different black body temperature for each color, that for red being lower than for green or blue. In this paper the term *temperature*, unless otherwise qualified, is taken to mean the black body temperature Centigrade, as given by an optical pyrometer using red light, $\lambda=0.66\mu$.

To study the selective radiation for dif-

Table I.
Calibration of Metal Filament Lamp, No. 11. (Red Radiation.)

Current in filament.	Observed temperature of filament.	Calculated temperature.	Obs.—calc.
0.1302	847°	848.2	—1.2
.1510	921°	919.2	+1.8
.1895	1049°	1051.2	—2.2
.2270	1166°	1167.2	—1.2
.2625	1267°	1269.9	—2.9
.3144	1413°	1410.7	+2.3
.4013	1621°	1625.2	—4.2
.4561	1750°	1750.2	— .2
.4812	1811°	1805.7	+5.3

Table II.
Radiation from Platinum.

Actual temperature of platinum.	Black body temperatures		
	Red $\lambda=0.66\mu$	Green $\lambda=0.55\mu$	Blue $\lambda=0.47\mu$
1100°	1008°	1029°	....
1400	1255	1285	1300
1700	1505	1545	1755

TABLE III.
EQUATIONS FOR TUNGSTEN LAMPS.

Lamp No.	Color.	Equation.
1	Red	$I = 1.008 - 0.0_3391t + 0.0_6548t^2$
5	Red	$I = 1.344 - .0_3396t + .0_6518t^2$
10	Red	$I = 0.802 - .0_3437t + .0_6490t^2$
10	Green	$I = 0.775 - .0_3390t + .0_6465t^2$
10	Blue	$I = 0.644 - .0_3225t + .0_6411t^2$
11	Red	$I = .028 + .0_3104t + .0_7990t^2$
11	Green	$I = -.060 + .0_3152t + .0_7781t^2$
11	Blue	$I = -.056 + .0_3148t + .0_7778t^2$

ferent colors, the filament F was calibrated with red, green and blue light, obtained by interposing monochromatic glasses at G.

The measurements were made in the range 700°-1,850°C., which was the safe upper limit of the carbon ribbon, C. Higher temperatures of F. were then obtained by extrapolation of the current temperature relation. As to the reliability of such extrapolation we have found that lamps calibrated to 1,300° were still in agreement to within 1° or 2° when extrapolated for 300°, and further that these extrapolations are in satisfactory agreement with other methods of measuring temperature.

Precision of Method.—As an illustration of the results attainable by this method we cite the measurements made on a 100-volt metal filament lamp, very probably tungsten.

SELECTIVE RADIATION.

Regarding the significance of selective radiation and its bearing upon the problem in hand, the radiation of platinum for red, green and blue, as compared with black body radiation, may serve as an extreme illustration. In the following table are grouped some results obtained from measurements of the black body temperatures of platinum for red, green and blue, at various known temperatures.

We may interpret these results as follows:

As a first approximation suppose that the platinum is at a true temperature of 1,700°, then its radiation for green light is equal in intensity to the radiation of a black body at 1,545°. The platinum radiation will be somewhat greater than that of this black body for blue light (viz.: equivalent to a black body at 1,575°) and somewhat less for red (viz.: 1,505°). The total luminous radiation of the two is, therefore, not very different, and as the maximum sensibility of the eye is in the green their photometric appearance will be very nearly alike. Now the maximum energy for both is in the infra red, and for these long wave lengths the black body temperature of the platinum falls still more behind that of the black body. It will be seen, therefore, that the energy of luminous radiation is distributed more favorably for platinum than for a black body.

In the calibration of the carbon filament pyrometer lamps against a black body, no appreciable difference (less than 2° C.) could be detected in the current temperature calibration equations using red, green and blue light. It does not follow from this, however, that the radiation from carbon is the same as that from a black body; on the contrary, carbon is known to depart considerably from ideal blackness, although in the visible spectrum it shows no appreciable evidence of selective radiation; and for this reason is sometimes called a "gray body."

TUNGSTEN LAMPS.

Four tungsten filaments gave the following current temperature relations, where I is the current in amperes in the filament and t is its corresponding black body temperature for the radiation (color) studied.

All but lamp No. 11 were low-voltage

TABLE IV.
SELECTIVE RADIATION OF TUNGSTEN.

Lamp No.	Black body temperatures: Red ($\lambda = 0.66\mu$)	Green ($\lambda = 0.55\mu$)	Blue ($\lambda = 0.47\mu$)	Approx. true temperatures.
10	1300° C	1310° C	1319° C	1355° C
11	1300°	1311°	1319°	1355°
10	1700°	1714°	1723°	1770°
11	1700°	1724°	1734°	1800°
10	2100°	2123°	2141°	2220°
11	2100°	2146°	2161°	2280°
10	2500	2532°	2565°	2690°
11	2500°	2576°	2594°	2780°
10	2900	2943°	2994°	3180°

experimental lamps designed with a view to studying the behavior of tungsten at high temperatures. The experimental data for lamp No. 11 are given above. (See Table I *et seq.*)

At normal voltage (100 v.) the current in this lamp was 0.644 amp., from which the corresponding temperature given by its equation is 2,135° C., indicating a true temperature of the filament of about 2,300° C. (See Table IV.) At 100 volts the candle-power of this lamp was 68 and its specific consumption 0.95 watts per candle (mean horizontal), from data furnished by Dr. Hyde, of the Bureau of Standards. Lamp No. 10 was burned at a temperature of 2,400° C., (about 2,570°C. true temperature) for 1½ hours when it burned out.

Selective Radiation.—The selective radiation of tungsten was studied as in the case of platinum by measuring the black body temperatures of the filament for red, green and blue light. The results as given by the equations of Table III are shown in Table IV.

The appearance of the filament of lamp No. 11 when cold was more polished than that of No. 10, and the table shows No. 11 to act the more like a bright metal such as platinum. Another lamp whose filament resembled that of No. 10 gave sensibly identical values with the latter. The last column in Table IV giving the approximate values of the actual temperatures of the tungsten filaments is obtained by adding to the black body temperature for blue light, twice the difference between the readings for red and blue light, a relation found to hold fairly well for platinum, which shows this selective effect much more than does tungsten. (See Table II.)

A filament, the composition of which was stated to be 30 per cent of tungsten and 70 per cent of zirconium nitrate, gave practically the same selective radiations as tungsten. When run at a temperature somewhat above the normal working temperature of the tungsten lamp, a rapid deterioration of the filament took place, accompanied by the formation of an iridescent deposit on the bulb.

Melting Point of Tungsten.—By noting the current required to burn out a tungsten lamp and substituting in the proper current temperature equation (Table III) an idea of the melting point of tungsten may be obtained. Lamps 1 and 5 were burned out at temperatures of 2,950° C. and 2,850° C., respectively, which indicates a mean true temperature of about 3,200° C, for the melting point of tungsten. Both filaments formed shiny beads indicating a real melting and not a disintegration due to evaporation as in the case of carbon filaments. There was no appreciable deposit in the bulbs after burning out. It would appear that tungsten has the highest melting point yet measured.

TANTALUM LAMPS.

We have thus far examined only two tantalum lamps, whose current temperature equations are given in Table V.

The filament of No. 9 had been broken and rewelded by shaking. No. 8 was the ordinary 110-volt lamp. At 110 volts the current was 0.380 amp., indicating a temperature of 1,865° C., or a true temperature of about 2,000° C. (see Table VI). This lamp was heated for one hour at the normal temperature of the tungsten lamp, 2,135° C., after which a recalibration showed a marked increase in temperature (about 2 per cent) for a given current. A further two hours' heating at the same temperature showed a further rise of 1 per cent. After standing ten days it recovered almost completely; the temperature of normal burning (110 v.) as determined from a new calibration being 1,870° C. Lamp No. 9 was burned at 2,200° C. for seven hours and showed the same phenomena, but to a greater extent, and there was a very marked blackening of its bulb.

The increase in efficiency of these metal

TABLE V.
EQUATIONS FOR TANTALUM LAMPS.

Lamp No.	Color.	Equation.
8	Red	$I = -0.0125 + 0.0_4538t + 0.0_7840t^2$
8	Green	$I = -.0392 + .0_4901t + .0_7687t^2$
8	Blue	$I = -.0607 + .0_3125t + .0_7531t^2$
9	Red	$I = -.0176 + .0_4617t + .0_7810t^2$

TABLE VI.
SELECTIVE RADIATION OF TANTALUM.

Black body temperatures			Approximate true temperature.
Red $\lambda = 0.66\mu$	Green $\lambda = 0.55\mu$	Blue $\lambda = 0.47\mu$	
1300° C	1320° C	1330° C	1360° C
1700°	1727°	1752°	1800°
2100°	2147°	2198°	2300°

TABLE VII.
EQUATIONS OF CARBON FILAMENT LAMPS.

Lamp No.	Type: Volts.	Type: Watts.	Equation.
3	50	4	$I = 0.156 - 0.0_3223t + 0.0_6532t^2$
4	50	4	$I = .092 - .0_4860t + .0_6460t^2$
6	50	4	$I = .087 + .0_5592t + .0_6388t^2$
7	50	4	$I = .166 - .0_3140t + .0_6394t^2$
7	After	2200°	$I = .066 + .0_4109t + .0_6352t^2$
13	110	3.1	$I = .067 + .0_5916t + .0_6156t^2$

filament lamps in the early stages of burning is well known. The above experiments indicate a rise in temperature during this stage of the burning. Sufficient data are not yet at hand to determine whether this is due to a smoothing of the surface with use as has been suggested or to an improvement in the vacuum with burning. If the increase in efficiency is due to an increase in the polish of the surface, and therefore in the selectivity of the radiation, it would probably result in further separating the red and blue calibration curves.

Selective Radiation.—In Table VI are given the results of measurements on the selective radiation of tantalum, as obtained with lamp No. 8.

For the sake of comparison with the metal filament lamps a study was made of the temperature behavior of some of the ordinary types of carbon filament lamps, including 4, 3.5 and 3.1-watt lamps. The current temperature equations of five of these lamps are given in Table VII.

With a view to determining the maximum temperature attainable with carbon filaments, several of these lamps were burned out by quickly increasing the current.

Owing to the rapid deterioration of the carbon filament the maximum temperature that can be attained depends on the rapidity with which the temperature is raised, the thickness and condition of the filament, etc. For these reasons it is impossible to state with precision the temperature at which the filament finally breaks down, as the calibration equation no longer applies but serves nevertheless to define a lower limit of the temperature of destructive disintegration, which varied between 2,500° and 2,800° C. for these lamps. At the normal working temperature of the tungsten (2,135°) the carbon lamp shows rapid deterioration.

The normal burning temperatures of lamps 3, 4, 6 and 7 ranged from 1,695° to 1,720°. Lamp No. 7 was burned at 2,200° for 15 minutes and on recalibration showed a normal temperature of 1,670°, or 40° lower than before. It was again heated one hour at 2,200° when it broke down at the pasted junction. The bulb showed considerable blackening and the resistance of the lamp rose from 36.7 to 41.5 ohms.

NORMAL TEMPERATURES.

The following table gives the normal burning temperatures of both the metal filament and the carbon lamps examined.

GENERAL DISCUSSION.

At a given true temperature the total energy of thermal radiation as well as that emitted per unit area by a black body, is greater than that of any other known body. No conclusive experimental evidence has yet been brought forward in contradiction to this general statement. On account of the very large proportion of the energy of total radiation that exists as the longer wave lengths of the infra red portion of the spectrum that do not excite the sensation of light in the eye, a black body is an inefficient luminous radiator.

Of all metals that can be raised to even a moderately high temperature (say, 1,500° or more) platinum departs farthest from black body radiation. For a given true temperature it radiates less total energy, and a larger proportion of this energy exists in the form of the shorter wave lengths which excite the sensation of light. This is the sense in which the term *selective radiation* is here used. If platinum could withstand the high temperatures at which these modern metal filament lamps can be worked it would, therefore, have an appreciably higher efficiency than they have. In this sense all solid substances show, in varying degrees, selective radiation and all are more

TABLE VIII.
NORMAL BURNING TEMPERATURES.

Type of Lamp.	Watts.	Volts.	Observed black body temps. (red).	Approximate true temperatures.
Carbon	4	50	1710° C	1800° C
Carbon	3.5	118	1760°	1850°
Carbon	3.1	118	1860°	1950°
Tantalum	2.0	110	1865°	2000°
Tungsten	0.95	100	2135°	2300°

efficient luminous radiators than a black body. For these reasons carbon, which is one of the closest approximations to a black body, is a less efficient luminous radiator than the metals. It should be remembered, however, that at the same true temperature a carbon filament would emit more light than these metal filaments, although on account of the greater selective radiation of the metals as shown above it would be less efficient.

In much of the literature on this subject the marked gain in efficiency of the metal filament lamps is attributed almost entirely to selective radiation, and it is often implied that the radiation is not only selective in the sense above discussed, but similar to that of a gas, which, when electrically excited, can emit strongly in one region of the spectrum while the radiation may be entirely absent for large regions. In support of this view the statement is often made that the character of the light from the tungsten filament is more greenish in appearance than from a carbon filament or from a tantalum filament unless there is a considerable effect of this kind in the infra red.

In this connection it should be stated that a few preliminary measurements made on the Nernst glower at low temperatures seem to show that there is an appreciable increase in the selective radiation for green light, the black body temperature for green light being almost or quite as high as for blue, which is in agreement with the experiments of Kurlbaum and Schulze. The nature of the conduction and of the chemical processes here involved is as yet but little understood. The undue increase in the emission for green light might suggest the combined effects of radiation from a solid and from a gas. The experiments of Kurlbaum and Schulze show that this effect almost disappears at higher temperatures, and the important fact remains that it is not this type of selective radiation that contributes materially to the efficiency of any of the metal filament lamps.

The measurements above cited show that tantalum is more selective in its radiation than is tungsten and in all probability would be more efficient than tungsten at the same true temperature. The great gain in efficiency in the tungsten lamp over the tantalum lamp must, therefore, be attributed to the very much higher temperature at which the tungsten can be worked continuously. Likewise the marked increase in efficiency shown by both tantalum and tungsten lamps over carbon filament lamps is to some extent due to selective radiation, but is rendered possible to a greater extent from the fact that they can be operated at a higher working temperature. The marked gain in efficiency resulting from an increase in the temperature is at once evident from the fact that at the working temperature of these lamps the intensity of the light emitted varies about as the twelfth power of the temperature while the electricity supplied to the filament varies as a much lower power of the temperature, something of the order of the fifth, varying with the material of which the filament is constructed and the nature of its surface. This is also illustrated by some measurements made by Dr. Lederer on osmium lamps from which it follows that the light increases as the 4.4 power of the voltage, while the consumption of electricity varies only as the 1.5 power of the voltage.

If a very considerable part of the gain in efficiency in the metal filament over carbon filament lamps is to be attributed to the higher working temperature at which they may be operated it may at first sight seem that this conclusion is at variance with the relatively high efficiency of these metal filament lamps in comparison with electric arc lamps where the luminous radiation comes from a source whose temperature is more than 1,500° higher. In the arc lamp, however, the loss of power by the conduction and radiation of the carbons and by convective circulation is so great that this fact is readily explained.

We are indebted to Mr. J. W. Howell for the carbon ribbon lamps and to Mr. J. A. Heany for most of the tungsten lamps.

FOREIGN ITEMS

THE MERCURY VAPOR ARC

From *Electrical Times,* London.

"If I place a candle flame and an open type arc at opposite corners of my roof on a still evening, and retire nearly three miles from the house across Hampstead Heath, why is it that I see the candle flame as distinctly as the arc, possibly rather more distinctly of the two?" When Mr. Bastian put this question to us, the only answer that immediately presented itself was that the arc must have illuminated the candle flame rather vividly and we suggested a fresh trial with a curtain in between. But this did not appeal to Mr. Bastian, who has some interesting theories of his own to account for the phenomenon. The intense light of the arc radiates from a point, whilst that of a candle flame or mercury vapour tube flows in parallel rays. Here are a few of Mr. Bastian's own words:

The further the photometric screen is from the source of light, the more nearly will the rays impinging on it be parallel to one another, and the lower the intrinsic light density at its source, the lower will be the light density of the approximately parallel rays in the intervening medium between the source of light and the screen; and, bearing this in mind, it will be apparent that, in the case of a carbon arc lamp, the light density in this intervening medium is about four thousand times greater than it would be in the case of a mercury arc lamp; and it is submitted that the transformation of light into obscure energy in that medium would take place in the same proportion; and if so, this would sufficiently account for the fact that illuminants of low light density, such as mercury arc lamps, incandescent gas mantles, bat-wing gas burners, etc., yield light of much greater penetrative quality than that yielded by an open type carbon arc.

Whatever the truth may be, experiment seems to show that mercury arc light has immense carrying power and it is also said to excel other illuminants in penetrating fog vapours. It is highly actinic, more so than the carbon arc, and this, together with its emission of parallel rays, renders it the best illuminant at the photographer's disposal.

Photometry of tubular light is difficult. A lamp, used for the illumination of a large workshop, which was stated to be giving 400 candle-power—and was certainly not giving much less—consumed two amperes at one hundred volts. The efficiency is about seven or eight times as high as that of small carbon filament glow lamps.

There is more than one mercury vapour lamp, of course. The best known rival of the Bastian is the Cooper-Hewitt. "Uviol" lamps made in Jena, are also on the English market, we believe, but the Cooper-Hewitt is unlike this in that it depends so largely upon its patents. A great number of patents have been taken out for the use of mercury vapour. We have before us the specifications of Christopher Binks, 1853; Professor J. T. Wray, 1856; C. W. Harrison, 1857; J. Rapieff, 1879; and H. J. Dowsing, 1896. If the last named patentee had not allowed his rights to lapse, it is most improbable that either the Cooper-Hewitt or the Bastian lamps would be in existence. We are now chiefly interested, however, in these two living types, and it is useful to inquire into the difference between them. One point that is very conspicuous in the Cooper-Hewitt, and lacking in the Bastian, is the large cooling chamber which is required for condensing the vapour. Then again, Mr. Bastian calls his lamp a mercury vapour *arc*. Mr. Cooper-Hewitt insists upon the fact that his lamp is neither a Geissler tube nor an arc, but a stick of vapour which heats up, as a resistance, on the passage of a current. These are his words:

The action thus described is different from that which takes place when alternating or intermittent electric currents of very high frequency are applied at the terminals of a Geissler tube containing a highly rarefied gas.

The action is also different from that which takes place in certain proposed apparatus wherein two electrodes consisting of bodies of mercury are contained in hermetically closed tubes, in such relation that an arc, fed by a suitable electric current, can be formed and maintained between the electrodes. As above stated, my apparatus does not act upon the principle of an electric arc, but its action appears to be caused by the passage of an electric current through a conducting medium having sufficient resistance to become incandescent, the medium in this case being a gas or vapour.

Compare this with one of the leading claims under the Bastian patents:

A mercury vapor arc lamp comprising a movable container for mercury electrodes or contacts in said container normally connected by the mercury in said container and means adapted to move said container and mercury and thereby strike the arc.

The accompanying figure, No. 1, will serve to show how the arc is started. There are two permanent resistances in series—their consumption is debited against the lamp in stating efficiencies—and two magnet bobbins. Normally the zigzag glass tube below rests in such a position as to be full of mercury from end to end. When current passes, the magnet tilts this tube up, the mercury in the tube flows back into a bulb, and the arc strikes. A little pumping happens sometimes, during the first half-minute, but perhaps no more than would occur with an ordianry arc. At all events, when the lamp settles down to work it will stand any amount of vibration. In fact it is not at all sensitive. For our benefit volts were lowered from 200 to 180 on a sample lamp, with very little dimming and no pumping. They were raised so far above 300 that the volt-meter

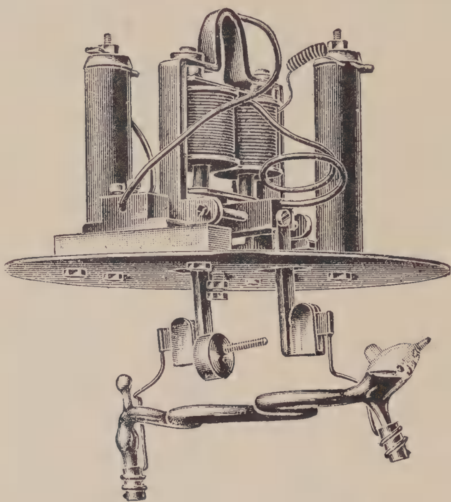


FIG. I.—ORDINARY TYPE OF MERCURY VAPOR ARC.

needle left the scale. The lamp always remained steady and did not glow as much more intensely as a carbon lamp would have done. The density of mercury vapour is greatly above that corresponding to maximum conductivity.

The mercury arc has, so far, only been used successfully with direct-currrent. It is possible that combination with cadmium and sodium may facilitate the production of an alternating-current lamp later on, and experiments are being carried out with a view to this result.

The life of the Bastian lamp may safely be stated at 5,000 hours. Lamps have been burning for over ten thousand hours, and they do not age much with use, the lamp is just as good after two or three thousand hours as it was when new.

And now as to color. This is a much vexed question. A new lamp showing a white moon-like glow has recently passed from the laboratory to the workshop. We found several red lines in the spectrum, and the light is comparatively pure. It centainly did not produce the violet finger nail effect of the more primitive mercury arc. Further experiments are being tried with cadmium and sodium, combined with the mercury in small quantities. No doubt a perfectly pure light will be the result. The Bastian lamps sold hitherto have been cured of their color defects by combining them with a small carbon filament lamp, or else by providing reflectors painted with rhodamine or surrounding with shades of red fluorescent material. Such combinations are quite satisfactory. The mixed light, in fact, is very similar in quality to sunlight, it throws no unpleasant colors on the face, and is excellent for matching patterns. An instance was given us of a West End tailor who is perfectly satisfied with the effect. The Ritz Hotel uses Bastian lamps, so do Waring and Gillow. Of course we have been used to yellow artificial light for such countless generations that when the last suspicion of color has been coaxed out of the mercury arc we shall probably want it made yellow. Kindly note our taste in flame arcs, if this be doubted! And it is a pity, because the mercury arc, already fairly pure, is comforting and restful to the eyes. Perhaps this is because of the low density of light in the tube, though. For factories and drawing offices the old type of unadulterated mercury arc may safely be prescribed. It is, at all events, preferable in color to the gas mantle.

The next point of interest is heat. The Bastian tube scorches paper and is decidedly hotter than a glow lamp. We are informed that 50 per cent. of the available energy is transformed into light, though probably this is altogether too sanguine a figure, it is enough to make the very glow worms wriggle. As a high temperature had to be fought, it was impossible to use the lead glass employed in the Cooper-Hewitt lamp, Jena combustion tubing was a possible solution. But its coefficient of expansion is lower than that of the platinum wire terminals which are sealed in to touch the mercury. The very ingenious method of overcoming this difficulty is the subject of one of the many patents. The platinum wire is made up in dumb-bell form. Ordinarily it is not a dead fit in the glass pin hole, although when heated it swells and effectively closes this pin hole. When it cools and contracts it draws the two ends of the dumb-bell against the ends

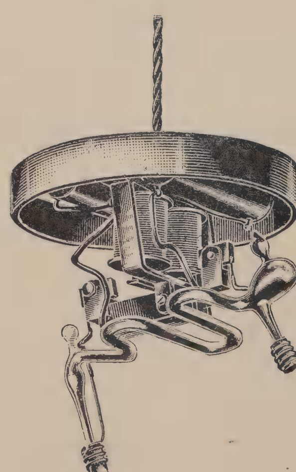


FIG. 2.—MERCURY ARC SUITABLE FOR COVERING WITH SHADE OR REFLECTOR.

of the pin hole. It is all so pretty that one marvels that it should ever work in practice. But it does.

And then, for those who have time to indulge in it, the mercury arc is full of fascinating theoretical questions panting to be answered. As a mater of fact mercury was found to be carried over from the positive to the negative electrode. When the positive end was depleted of mercury, trouble naturally arose.

Taking it as proved, then that mercury is transferred, during the operation of the lamp, from the positive to the negative electrode, due to some effect of the electric current other than heat, it was conceived that this could be compensated for by transference of mercury in the reverse direction, if the negative electrode could be maintained at a sufficiently higher temperature than the positive; and by constructing the burners so that the negative electrode surface is smaller than the positive, this compensating effect is actually obtained, with the result that constant quantities of mercury are retained at each electrode respectively throughout the operation of the burner.

If the theory is correct, there is a stream of vaporised mercury passing from the negative to the positive electrode, due to the difference in heat potential, and a stream of ionised mercury passing from the positive to the negative electrode, due to the difference in electric potential; and whether the theory is correct or not, the result remains the same, namely, that the migration of the mercury from the positive to the negative electrode is compensated for, or prevented.

A comparison of notes as to what takes place in the Bastian mercury arc, the Cooper-Hewitt hot mercury vapour resistance, and Geissler tubes, should be of no little interest just now, especially to those interested in the Election Theory.

THE MERCURY VAPOR LAMP

By H. Boas.

Extract from a paper read before the Electrical Association, Dresden, Germany, September 13, 1906.

From *Elektrotechnische Zeitschrift,* September 13, 1906.

In giving a history of the development of the mercury vapor lamp, the writer paid a special tribute to the fundamental work done by Arons, and referred to his own opportunity for research in this line in the physical laboratory of the University of Berlin. He also refers to the lamps designed by Gumlich at the direction of the government laboratory authorities, and states that the work of these early experimentors developed all the theoretical points of construction used in the present commercial lamps. He states, however, that full credit should be given to Cooper-Hewitt for bringing the lamp to a commercial stage. Speaking further on the general principles of the lamp he says:

"The mercury vapor lamp has attracted much attention, principally by reason of its convenient form and high efficiency. A lamp measured in the government laboratory with a current consumption of 3 to 3½ amperes showed an efficiency of .52 watt per candle without the resistance coil, and .88 watt with the resistance. The lamp had a counter EMF of 65 volts and was operated on a 110 volt circuit. The intensity perpendicular to the axis was 494 HK, and the mean spherical intensity 388 HK. By means of a new and somewhat different construction the lamp of Boas can be raised to a counter EMF as high as 90 volts with 110 volts at the mains, leaving only 20 volts to be taken up by the resistance, thus giving a proportionate increase in efficiency. The lamp is started by tilting it, thus short-circuiting the mercury in the tube. On returning to its original position, the mercury separates and strikes the arc. It is impossible to use a high tension current in starting the lamp if they are properly made i. e., with a high degree of vacuum. Only lamps with poor vacuums or those which are previously warmed can be started under high tension. The vacuum in the lamps should be as nearly perfect as possible, and the lamp perfectly clean. Even small particles of dust or soil, especially of a greasy nature, greatly injure the lamp; the efficiency at once falls, and the lamp gives a flickering, unsteady light, of a disagreeable yellowish color. The production of this high degree of rarefaction introduces many difficulties which can be overcome only by the most perfect system of exhaustion in connection with thorough cleansing. A good lamp may be said to contain a perfect vacuum. Between the vacuum of a good lamp and that of a Roentgen tube, there is as great a difference in pressure as between ordinary pressure and that of the Roentgen tube. The fact that Cooper-Hewitt lamp can be started under high tension is proof that the manufacturers have not succeeded in making a thoroughly good vacuum. Lamps of poor vacuum are very sensitive to oscillations, which cause a change in the tension of the mercury vapor. For this reason they operate satisfactorily only when provided with a compensating space, that is to say, with a so-called condensing chamber. This is a comparatively cool chamber, formed in the lamp tube, on the walls of which a steady condensation of mercury takes place. The higher the vacuum, the less such condensation takes place.

The shape and dimensions of the positive electrode are also of great importance. The best results are obtained by tube-shaped electrodes of large diameter, which are secured in long holders, forming at the back a cooler portion, which serves as a condensating chamber, and at the same time affords a means of

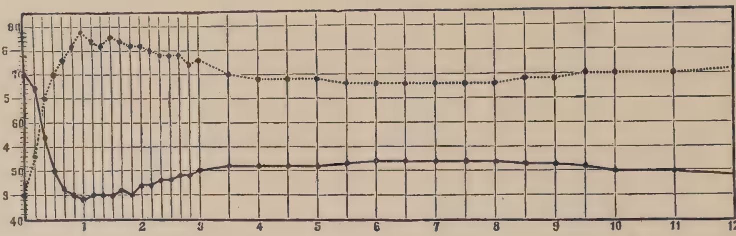


FIG. I.

fastening the electrodes. By this new arrangement frequent breakage of the electrode is avoided. The glass body of the lamp must be made of glass absolutely free of magnesium, as otherwise in a comparatively short time a very perceptible darkening takes place, which greatly reduces the intensity of radiation. The light contains a great quantity of ultra-violet rays, which are, however, completely absorbed by ordinary glass, so that the lamp even in immediate contact with the body can do no harm. The current which passes through the lamp must not be considered as a simple continuous current, but may be understood by conceiving a system of rapid, alternating current explosions imposed upon the main continuous current. These alternating current explosions are audible in a telephone receiver and should be at the rate of about 5,000 per second. These alternating currents induce a counter EMF and if this counter EMF rises to the tension of the main current, the lamp will be extinguished. In order to avoid this it is best to provide a large self-induction coil in the circuit of the lamp, for the purpose of choking down these alternations. From the moment of starting, the portion of the lamp is represented by peculiar curves shown in Fig. 1. The strength of current is shown by the continuous line, and the tension of the voltage by the dotted line. For the first three minutes, observations were made every ten seconds, after which up to twelve minutes every thirty seconds. After twelve minutes operation the proper voltage is generally reached. The curve is plotted for a tension of 112 volts. It will be seen that the counter EMF begins at 45 volts, corresponding to a current strength of 5. amperes. The voltage then rises rapidly, the amperes following proportionately. At 79 volts, after one minute's operation, the voltage reaches its highest value, while the amperage falls to its mimimum, 2.9 amperes. The voltage then falls as the amperage increases, and finally in about eight minutes the curves begin to diverge. Though the curves are still diverging in the figure, after twelve minutes' operation their course is nearly parallel. The oscillations shown in the voltage curve at three minutes seem to be due to the first condensation of the mercury, and to the changes of pressure which take place by the warm mercury falling back. This starting curve is characteristic of every lamp, the thickness of the glass walls principally determining the time. The extraordinary rise of voltage accompanied by a fall of amperes may be attributed mainly to an excessive formation of mercury vapor. The condition of stability is reached as soon as the glass parts have obtained a constant temperature, as determined by the warm mercury vapor inside and the cool air outside the tube.

PHOTOMETRIC AND SPECTROSCOPIC MEASUREMENTS OF THE MERCURY ARC OF HIGH VAPOR DENSITY

Measurements on the mercury arc created under the high vapor density were recently carried out in the laboratory of W. C. Heraus. The lamp under investigation was the new quartz glass mercury lamp in which the arc could be produced under a pressure of several atmospheres. Under these conditions not only were the lines of the spectrum visible, but also a continuous spectrum appeared. The intensities of the visible and ultra-violet rays were measured with different wattages. It was found that the efficiency of the two radiations has a maximum, and that the mean spherical intensity for visible rays reaches a value of .185 watts per standard candle, and that the intensity of the ultra-violet rays increases more rapidly than that of the visible rays. In the continuous spectrum the shorter rays increased more rapidly than the longer ones, while in the line spectrum a different increase of intensity appears in the various groups as shown by the isocromatic curves for the continuous spectrum and eleven of the brightest lines of the line spectrum.

ANNALEN DER PHYSIK.

ILLUMINATION OF THE OPERATING PAVILIONS IN THE PUBLIC HOSPITALS IN HAMBURG

By A. Zandt.

From *Elektrotechnische Zeitschrift,* Oct. 11, 1906.

When the plans were formulated for the lighting installations for the operating pavilions to be built for the two public hospitals of Hamburg, a number of men were chosen from the office of the Inspector of Electric Illumination to decide upon the method of illumination. Measurements of the illumination in the old Pavilion of the Eppendorf Hospital made with a Kruss illuminometer showed an intensity of about 170 meter candles at the height of the operating table (one meter above the floor.) This illumination was furnished by the use of ten 32CP carbon filament electric lamps fitted with a silvered reflector, and placed at a height of 2.3 meters, or a distance of about one meter above the table. This method of illumination, however, developed various disadvantages. The great amount of heat projected from the reflector above their heads was found very annoying by the surgeons; the effect being more and more perceptible as the operation continued. Another and greater disadvantage was in the intense shadows cast, in consequence of the light source being concentrated into a single space, which was exceedingly troublesome, especially in the case of postmortems. Besides this reflector arrangement, table lamps were often necessary. From wide experience the following requirements were made for the new illuminating apparatus to be provided:

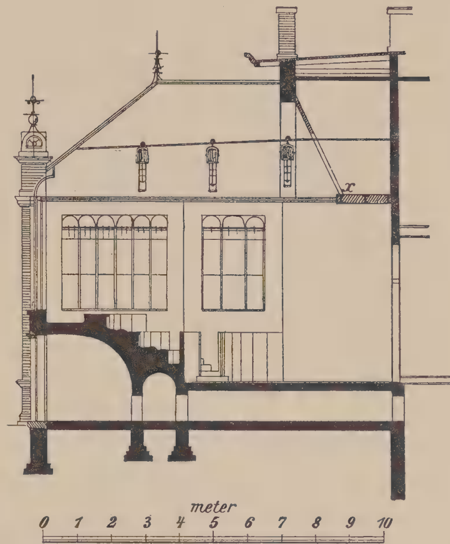
First: A high intensity of illumination,

Second: The greatest possible degree of diffusion,

Third: A minimum radiation of heat,

Fourth: A perfected method of arranging the illuminating units so as to offer the least possible opportunity for the collection of dust.

Fig. 1 shows the new operating pavilion of the Eppendorf hospital in plan and elevation. The pavilion is in the front part of the general operating room; adjoining it, and separated from it by a hand rail of about one meter in height, is an auditorium of ampitheatre form. As may be seen from Fig. 1, the large extent of window service gives superb daylight illumination. In addition to this, the room is fitted with a sky-light, which is furnished over the operating pavilion with a ceiling of obscured glass, as indicated by the dotted line, ABCD.



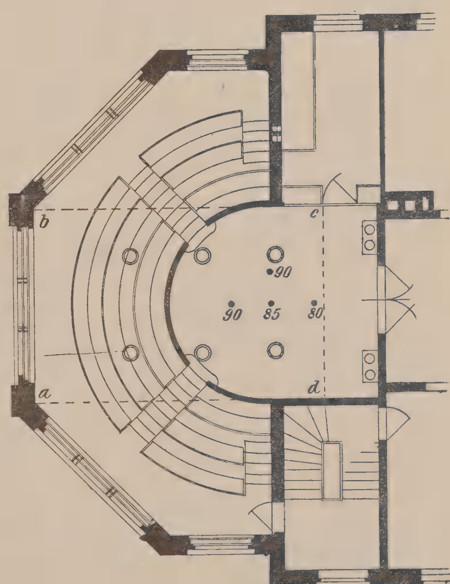


FIG. 1.—OPERATING PAVILION IN THE EPPENDORF PUBLIC HOSPITAL.

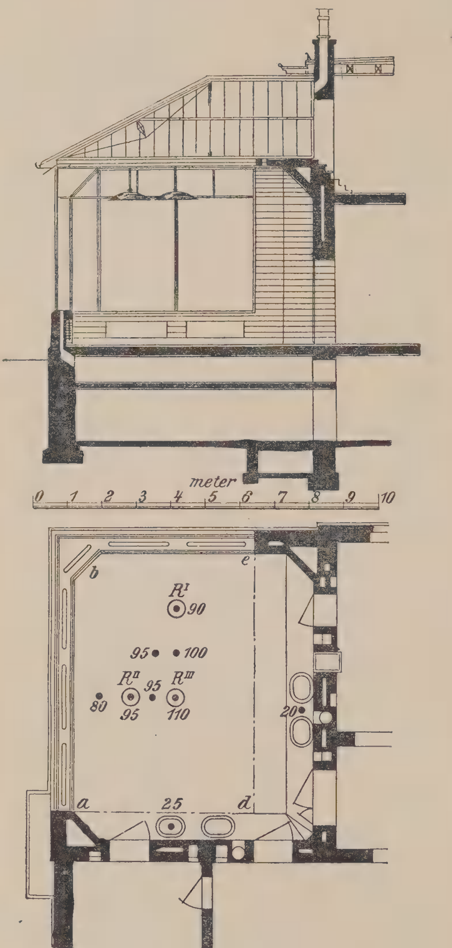


FIG. 2.—LARGE OPERATING PAVILION IN THE ST. GEORGE PUBLIC HOSPITAL.

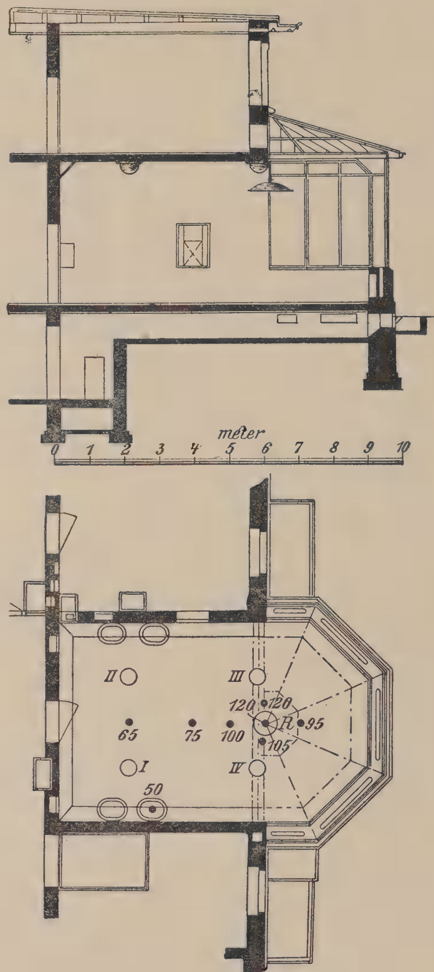


FIG. 3.—SMALL OPERATING PAVILION IN ST. GEORGE PUBLIC HOSPITAL.

The artificial illumination is produced by six 15 amp. direct current arc lamps. These are suspended above the glass ceiling from rollers running on slightly inclined bars, so that they can be drawn into a position above the operating table by means of wire cables attached to them. Experiments showed that the best illumination was obtained when the lamps were used open, i. e., without glass shades. Besides giving the greatest amount of illumination, this arrangement has the advantage of preventing the shadows which would be thrown upon the glass ceiling by the wire netting, globe-holder and glass globe. The lamps are ingeniously arranged so that the unavoidable shadows of the carbon holders fall in the direction of the frame work in the glass ceiling. The stations at which measurements were made of the illumination on a horizontal plane at about one meter in height in the space about the operating table, are indicated in the diagram; the corresponding numbers showing the illumination in meter candles. Although the intensity of about 90 lux which was secured in the old operating pavilion is far from being reached, the diffused illumination now obtained fully answers the requirements. Long experience shows that a uniform illumination is far superior to a considerably stronger, but less uniform intensity.

The large operating pavilion of the St.

George Hospital is shown in Figure 2. In this case the placing of the light-source over the glass sky-light is impossible on account of the construction of the roof, so that the artificial illumination had to be furnished from illuminating apparatus within the pavilion itself. For this purpose three reflectors were used, one over each of the operating tables, and the third in the center of the room to give general illumination. The focus height of the reflectors is four meters, so that the operator experiences no annoyance from the radiation of heat. Each reflector contains twenty-one 32CP Osmium lamps, and in order to give uniform distribution of light is covered on the bottom with a disc of frosted glass. The Osmium lamp was chosen, not only on account of the saving in current, but also on account of the smaller radiation of heat, and the whiter light which it produces. All angles, and attempts at decoration on the reflectors, which might collect dust, were avoided. The illuminating units are furthermore constructed with a regard to the necessity of spraying the walls and ceiling of the pavilion; the requisite openings for ventilation suitably protected from the spraying being provided.

The values of illumination given were obtained at the stations as shown in Fig. 2 the locations being along the side walls of the pavilion over the wash tables. The measurements were made after the pavilion had been fitted out with the necessary apparatus, such as operating tables, wash tables, instrument cases, etc.; the installation having been in use for some time, the candle power of some of the lamps had become reduced. The small pavilion in the St. George Hospital is shown in Fig. 3. In this case, also, the ceiling construction was such that it was necessary to place the illuminating units within the pavilion. A reflector similar to the one in the old pavilion is placed 3½ meters above the operating table. For the general illumination, 4 bowls of diffusing glass, each containing six 32CP Osmium lamps, were placed on the ceiling. The illumination obtained is shown in Fig. 3. It will be noted in regard to the wiring that steel conduits were placed above the ceiling with the switch placed in the corridor. The requisite sockets and plugs for connection with hand lamps and surgical apparatus in the operating pavilion are placed in nickel plated boxes, the covers of which are attached to the wall. The walls and ceiling are covered with white tiling; the doors are of white enamel: the windows are of obscure glass, and the floor covered with shiny material, so that the reflection from the walls and ceiling increases the illuminating effect.

Besides the pavilion of the general operating rooms above described, operating rooms are also provided in the separate wards, in which minor operations are performed. In one of these, the illumination of which was provided in accordance with the demand for high intensity, there is much complaint on account of the heat radiation from the reflector. The illumination is provided by a silvered reflector containing three 25CP carbon filament lamps at about 2.3 meters above the operating table, and a wall bracket placed above the wash table. The illumination about the operating table, at a height of about one meter above the floor, is from 75 to 125 lux, and over the wash table, 35 lux. These high intensities are largely due to the fact that the voltage runs from 112 to 115, instead of the normal, 108. Furthermore, the reflector was new. The disadvantages of the formation of shadows mentioned at the outset as a result of an illumination from a nearby source, were very conspicuous in this case.

THE ELECTRICAL REQUIREMENTS OF A HOSPITAL

By W. Cross, A.M.I.E.E.

From *Tyneside Electrical Pioneer*, Oct., '06.

The whole of the internal lighting is by electricity, no other illuminant being used. There are about two thousand incandescent lights and nine arc lamps; the current being supplied from the mains of the Newcastle and District Electric Lighting Co., Ltd., at a pressure of 240 volts.

Some of the fittings are of special interest, the wards being lit by brass pendant fittings fixed in the center, arranged so that a dim or bright light can be obtained as required, and, in addition, an especially designed wall bracket is fixed over each bed, while wall sockets are provided at every other bed for use with standard or hand lamps.

In the hall, library, board-room and other principal rooms, especially designed fancy fittings have been used, and the chapel is lit by a ring of lights fixed to the dome, and by fittings finished to imitate armour hung from the arches.

The operating theatres have received great care to ensure a good, handy light, and, in addition, emergency lighting, on the system patented by Mr. Hugh McGilvary, of Newcastle, has been installed, so arranged that should the ordinary source of light fail from any cause, the emergency light will be lit automatically, enabling an operation to be completed without danger or inconvenience. The laundry is lit partly by arc lamps and partly by incandescent lamps, while the subways are also well lit, to avoid the danger of the use of naked lights.

"HARRISON" UNIVERSAL PHOTOMETER

Messrs. Elliott Bros., of Century Works, Lewisham, call this a "universal" photometer, because it can be used to measure the illumination derived from, or the candle-power of, a lamp of any nature, under a large variety of conditions, such as are found, for instance, in the test room, in an ordinary room, or in the street.

They do not claim that the instrument measures with such a degree of accuracy as to be of use for standarding standard lamps, for the reason that the instrument itself depends for its operation on the substandard it contains; but for practical purposes, in the hands of an intelligent operator, it can be relied upon to give results within 5 per cent. The instrument is calibrated in candle-feet, which reading it is only necessary to multiply by the distance squared of the photometer screen from the lamp under measurement, to reduce it from candle-feet to candle-power.

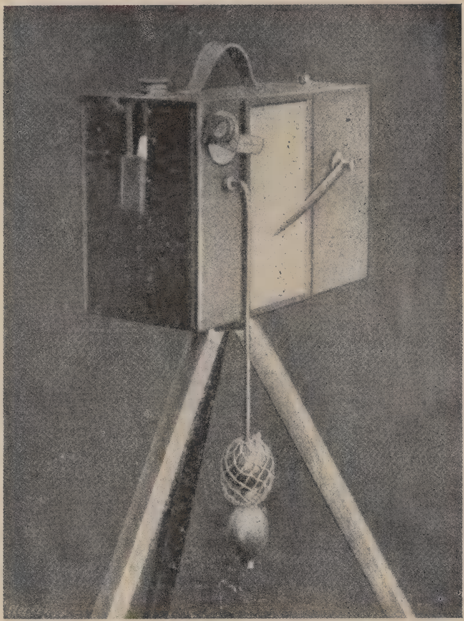
The chief novelty of this instrument lies in the fact that it embodies a flicker disk, somewhat of the Whiteman pattern, but rotated by a blast of air under the control of the operator. This not only results in the instrument being suitable for measuring all types of lamps, of which the spectrum varies considerably, but also in a light, portable and inexpensive instrument.

In order to make the instrument compact and easy to operate, the photometer bar and sliding lamp have been replaced by a reflecting screen with an angular adjustment; this is moved by means of a pointer attached to it. Thus the balance can be rapidly obtained, and the illumination read off direct from the scale.

The dimensions and weight of the instrument are such as to make it easily portable; the instrument, with the exception of the stand, is self-contained and always ready for use.

The instrument should be set up at a distance of about 10 ft. from lamps of 20 to 50 c. p., the distance being increased in proportion roughly to the square root of the candle-power, and reaching 60 ft. for 800 to 2,000 c. p. It is not essential that the instrument should be absolutely level; but the angle of incidence should be taken (by turning the sector lens so that the light spot falls on the line, and then reading the angle) in order to correct for the angle of incidence as shown in the correction table.

The opening exposing the sector disk should be pointed towards the source of light, so that the light falls on it at right angles to the horizontal. The distance of the lamp from the disk can be measured by the knob on the side of the instrument which is placed there for the purpose.



HARRISON UNIVERSAL PHOTOMETER.

Having set up the instrument, all that is necessary is to rotate the sector disk by means of the air-pressure bulb provided for the purpose. The standard lamp, having been lighted by inserting the plug, the pointer can be moved until that position is arrived at when the operator, looking through the telescope, can see no flicker. The pointer will then read the illumination in candle-feet at that distance from the light, and at that angle of incidence, indicated by the lens and sector on the edge of the instrument.

From time to time it may be considered advisable to check the instrument. This can easily be done by fixing a lamp of known candle-power (preferably an incandescent electric, with a known voltage) at various distances from the instrument, and making measurements. Care should be taken to do this in a room having walls with little reflective power, or in the open on a dark night.

STANDARD OF ILLUMINATION

Electrical Review, London, Oct. 19, '06.

The writer of the notes upon gas engineering and supply contributed to the "Engineering Supplement" of *The Times* has discovered the need of a recognized standard of illumination, and in the following note sets forth his views. "The

urgent need of some generally recognized standard of illumination has been repeatedly referred to in these columns, and the recent controversy as to the respective merits of electric lighting and the most improved systems of using gas with the incandescent mantel or under compression has again brought this question into prominence. For those who have not made a study of this subject the fact that great differences of opinion exist among scientific men even upon such a comparatively simple matter as the intensity of the light of the sky on a bright, clear day will occasion some surprise. It has been stated that the standard assumed as representative of 'diffused daylight,' or the light of the zenith, measured at noon on a cloudless day about the period of the summer solstice, is a variable one, and fluctuates very widely for different localities. This may probably be due to reflection from the earth's surface, and would render it necessary to fix upon a value by careful observation for each district. It is, however, not essential to select such an intense light as diffused daylight for the standard of comparison, and oil lamps, pentane gas lamps, and candles have served at different times and in various countries for photometric units. What is really needful is that experts should agree upon some uniform standard, and that we should have definite scientific estimates of results for the guidance and information of the public. This subject of lighting is one which should be settled by reliable and accurate observations, and not by 'mere prejudice and opinion.' "

TEST OF WOLFRAM AND OSMIUM LAMPS

Mr. F. Uppenborn reports the following results from tests made on Wolfram lamps in the laboratory of the municipal electric plant of Munich. Tests were made with new lamps of four different kinds, viz.

1. The ordinary carbon filament lamp,
2. Tantalum Lamp,
3. Osmium Lamp,
4. Wolfram Lamp.

All lamps were made to run at 110 volts and gave me following results measured before the tests:

Kind of Lamp	Amperes	Watts	Candle-power	Efficiency
Carbon filament	0.536	58.9	16.7	3.53
Tantalum......	0.400	44.0	27.3	1.61
Osmium.......	1.012	111.0	63.4	1.76
Wolfram.......	0.520	57.2	57.0	1.00

TABLE I.

In the test the voltage was increased by steps of five volts each, beginning at the lowest voltage at which the light intensity could be readily measured, up to 120 volts, beyond which the increase was by steps of two volts up to the maximum voltage; above which the measurements began to be uncertain. At each voltage the amperage, wattage, efficiency, and intensity of light were determined by three settings of the photometer. The results are shown in Figures 1 to 4, the values being expressed with reference to percentages of the standard value of 110 volts. The series of observations for each lamp were taken as quickly as possible so that the intervals between the changes in voltage were of the same duration, in order that the changes in the structure of the filaments might be as small as possible.

A carbon filament lamp tested by a Hefner lamp before and after the experiment was used as the secondary standard in the measurements. Immediately after the highest voltages had been measured for each lamp the measurement at 110 volts was repeated which gave the following values expressed in percentages of the first measurements. The highest voltages at which the various lamps were tested were as follows:

1. Carbon filament lamp: 175 v = 150% of 110 volts
2. Tantalum Lamp: 2100 v = 191% of 110 volts
3. Osmium Lamp: 170 v = 152% of 110 volts
4. Wolfram Lamp: 180 v = 164% of 110 volts

TABLE II.

The characteristic difference between the carbon filament lamp and the metal filament lamp is especially noticeable in the curves showing the amperage. In the case of the carbon filament lamp, owing to its negative temperature coefficient, the amperage curve bends upward, while in the other it turns in the opposite direction. The ampere curve of the Osmium lamp is peculiar in that toward the end it bends downward. These extremes show that the Wolfram lamp is nearly indifferent to variation in voltage.

The following report comes from the laboratory of Dr. Lux, in Berlin. Three 32-candle-power lamps obtained from the Auer Co., in Berlin, were tested. In order to compare the results with those obtained by Upperborn the same method of procedure was followed. The results are shown in the curves Figs. 5 to 8. In order to make the comparison complete, the curves for the carbon filament lamps have been plotted on the same diagrams. The results show plainly that the behavior of the Osmium lamp coincides very nearly with that of the Wolfram lamp, both in its electrical qualities and in light produced

Miscellaneous News

Alameda, Cal.—Park street merchants have decided to petition the Trustees to furnish the power for the better lighting of that thoroughfare. The merchants decided to install eight electroliers on each block between Lincoln and Encinal avenues. The style of lamp chosen is similar to that being installed on Broadway in Oakland.

Albany, N. Y.—The Onondaga Lighting Company of Syracuse, which will manufacture and supply gas and electricity for light, heat and power purposes, has been incorporated with a capital of $1,000,000. The directors are L. Bedell Grant and William J. Bagnell, of Brooklyn; Ashley T. Cole, Arthur McCausland and James A. Byrne, of New York City.

Atlantic, Ia.—The people of Atlantic will vote on the question of selling the city electric light plant to Messrs. Ross & Judd for $30,000 and granting the company a twenty-five year franchise to the use of the streets for light, heat and power, and also granting the same company a twenty-five year franchise for the use of the streets for the purpose of operating an electric line.

Clinton, Mo.—Clinton has let the contract for a municipal lighting plant and advertised for bids for the municipal water works. The cost of the two will be $100,000.

Joplin, Mo.—The Joplin Light, Power and Water Co., of Joplin, filed articles of incorporation today, with a capital stock of $25,000 divided into shares of $100 each half paid in. The shareholders are James Campbell, St. Louis, $24,600; W. F. Reed, St. Louis, $100; John P. Newell, St. Louis, $100; H. R. Conklin, Joplin, $100; A. A. Jones, Joplin, $100.

Long Beach, Cal.—By order of the City Trustees, Attorney Daly is preparing a resolution calling for estimates and plans for a municipal lighting plant. Estimates will be asked for a plant sufficiently large to furnish lights for commercial as well as municipal use.

Los Angeles, Cal.—Initial steps toward better lighting of the principal business streets of the city have been taken by the trustees. They have ordered telephone, telegraph and street railroad companies to place their wires underground in the eleven blocks to be lighted by the pole system, and have secured estimates on iron poles and lights. The property owners agree to pay for the poles, which will cost $100 each, and the city will install the wires and furnish the light.

McCool, Neb.—At a meeting of the town board an ordinance was passed Friday granting Clark R. Burnham of Grand Island rights and privileges to maintain and operate an electric light and power plant and a system of water works.

Morgantown, W. Va.—The streets of Morgantown are to be illuminated with electric lights. The city council passed an order last night directing a special committee to make arrangements for the installation of 32-candle-power and 50-candle-power incandescent lamps to take the place of the open gas lights as soon as possible.

Paterson, N. J.—Municipal ownership of water and light won a victory here yesterday. The vote for the water plant was 8,040 for, to 1,234 against, and for the lighting plant, 8,140 for, to 1,766 against.

Portland, Ore.—A state light and power plant of sufficient size to furnish light and power for all the state institutions and buildings at Salem will in all probability be one of the most important questions to be discussed by the state board for presentation to the legislature.

Riverside, Cal.—Telephone and telegraph companies will be requested to put their wires underground in the business part of the city, in order to make possible the installing of a system of ornamental cluster lights similar to that in use in Los Angeles and Pasadena. Iron posts will be used with four to the block, on each side of the street, and the lights will follow the mission style, in harmony with the architecture of many of the principal buildings along the thoroughfare to be lighted. The globes will be in the form of mission bells, clustered about the top of the poles.

St. Catharines, Canada.—There seems to be a strong probability that the Stark Electric Company will tender for the street lighting contract in this city when the present contract expires next month. The city is at present paying $75 per year per arc lamp to the Cataract Power Company for street lighting, and it has long been regarded as a very high figure. Experiments in lighting the streets with natural and manufactured gas and with the newest electric lamps are now in progress, and it is expected that a saving of at least $2,000 a year in the lighting bill will be effected.

Woonsocket, R. I.—Alton D. Adams of Worcester, Mass., an expert in matters concerning the cost of the manufacture of illuminating gas and other matters relating to the business will conduct an investigation of the Woonsocket Gas Company on behalf of the city.

The city will engage Mr. Adams, who will be paid for his services at the rate of $25 a day.

The Illuminating Engineer

Vol. 1 DECEMBER, 1906 No. 10

Public Lighting in Chicago

I. INTERIOR ILLUMINATION

By S. Morgan Bushnell.

The term "Illuminating Engineering," while common enough today, is one which, a few years ago, was almost unknown. And this fact reminds us that a new science, or rather a new art, has recently come to the world. This does not mean that illumination is a new thing. It is the application of scientific principles to illumination which is new.

When the incandescent electric lamp was first introduced it seemed almost a step backward. Already gas was commonly used for lighting in all of our large cities and the new light was not only more expensive but from its intensity, more trying to the eyes.

I know there are many electrical experts who would be inclined to dispute this statement, but when we remember that the ordinary gas flame has a brilliancy of 4½ candles to the square inch while the 16 candle-power incandescent lamp has a brilliancy of from one hundred to two hundred candle-power to the square inch, we must realize that the bare unshielded lamp must be of necessity more trying to the eye than the milder intensity of the ordinary gas light or the soft flame from an Argand burner.

The writer has been informed by the best oculists that for reading purposes the ordinary student lamp, using kerosene oil, is the best substitute for daylight.

The electric light has, however, various advantages which, in all probability, will make it pre-eminently the light of the future.

Without going into the matter in detail we may mention the freedom from dirt, the fact that there is no consumption of oxygen from the air, and adaptability to almost any position, all of which renders it a light especially suitable for the requirements of illumination.

The great objection to the electric lamp, namely, its intensity, can easily be overcome by the use of ground glass and prismatic shades; and this brings up the need of an art of scientific illumination.

For several years it was considered rather extravagant to use frosted lamps, as that would mean the cutting off of from fifteen to thirty per cent. of the light. We have only progressed a short distance beyond this point, but already those of us who have given any thought to the subject appreciate the utter barbarity of the old scheme of lighting by bare incandescent lamps.

Physiologists tell us that the ordinary eye can stand a brilliancy of from four to six candle-power per square inch of surface and anything beyond this will eventually cause irritation and inflammation to the retina and delicate adjacent membranes. It is very evident therefore that an incandescent lamp

filament with a brilliancy of 100 to 200 candle-power to the square inch would be highly injurious. Those who are blessed with eyes of extraordinary strength possibly may not appreciate this, but the vast majority of people have already learned how true this is.

There is a certain large theater in the city of Chicago which was built about eighteen years ago and which still uses the same style of illumination as was customary at that time, namely, bare incandescent lamps studded along the walls and ceiling. Another theater on the south side is illuminated by arc lamps placed so low down as to be within the range of vision.

While the improper lighting of public buildings is doing a great deal of damage there is probably a great deal more injury being done by the improper lighting of offices. It is very much easier to light an office improperly than to light it properly from a physiological standpoint, and the result is that ninety-nine cases out of a hundred have the lights so arranged that the artificial light used is very trying to the eyes.

The above points out the need of scientific illumination from a physiological standpoint. There is also a need from the esthetic and decorative point of view.

Any woman who has made a study of home decoration knows that bold pronounced colors in carpets, rugs or furniture are incompatible with the finest effects. Persian rugs, which are so much sought after, are especially desirable when made in the more quiet and less pronounced colors. In like manner it is impossible to produce an elegant and luxurious effect in illumination with the brilliant glare of the arc lamp or the unprotected rays of the incandescent. If we turn to nature we will find that the clear daylight which comes in through a north window on a summer's day is the closest approach to perfect illumination that has thus far been found. A moment's reflection will show us that this light does not come directly from any particular source, but is the product of a multitude of complex inter-reflections between the fields and the sky and is therefore a perfectly diffused light.

In making our artificial light we should therefore aim not only to have the color of the light similar to daylight, but should also aim to secure as complete a diffusion of the light as possible.

If we turn now to some examples of illuminating engineering here in Chicago, we will find that the objects which we have outlined have been secured: 1st, by placing the lights outside of the field of vision; 2nd, by using devices such as crystalline and ground glass for diffusing the light.

A very fine example of diffused lighting may be found in the barber shop recently opened up by the Chicago Athletic Association. It is probably one of the finest rooms of its kind in the country. The floor and wainscoting of the room are of white marble. The ceiling and upper portions of the walls are finished in cream with a gilt stripe. About 75 16 candle-power lights are used to illuminate the entire room. Every one of these lights is concealed by holophane prismatic glass. With the exception of the ceiling the room seems to be flooded with light and at no part is there enough light to be in the slightest degree annoying. In the ceiling are six large bowls of prismatic glass, like inverted punch bowls, which shed a soft glow from their entire surface, while around the walls are distributed bracket lights, which are enclosed with diffusing prismatic globes. The effect of these diffused sources of light combined with the inter-reflections from the mirrors and walls is such that one can read with perfect ease at any point in the room and yet, at the same time, the light is softened and adapted to the most sensitive eye-sight.

The new Federal Building in Chicago has been criticized by some as

BARBER SHOP, CHICAGO ATHLETIC CLUB.

not having sufficient light. The idea here has been, however, not so much to produce a glare of light as to produce a soft and suitable illumination. Everywhere you will find the lights toned down and mellowed by prismatic glass, which produces a pleasing effect very different from that found in the halls of the ordinary office building.

The Rookery building has just been re-decorating the main rotunda on the first floor and here we find another example of soft and pleasing illumination. The lights, enclosed by crystalline globes are suspended far above and shed a soft and mellow light throughout the main rotunda and at the same time bring out clearly the beautiful effects of the gilded marble wainscoting.

Turning from the Rookery building and stepping into the new Railway Exchange building, we find a scheme of lighting arranged on an entirely different plan from the Rookery building and at first sight the lights will appear to be arranged in accordance with old ideas. The effect, however, is not so bad, as most of the lights are outside of the ordinary range of vision and with the exception of a few low candle-power lamps the illumination is by means of frosted globes.

A good example of concealed lighting is found in Orchestra Hall, the new home of the Theodore Thomas Orchestra. As shown in the illustration, the lights are for the most part concealed, the entire illumination of the stage being accomplished by the so-called cove lighting. This result, so pleasing to the eye, is not as difficult as it sometimes at first appears and the best architects to-day are planning the illumination of halls, theaters and churches so that the light will be concealed from the eyes of the audience.

ROTUNDA, ROOKERY BUILDING

Occasionally, where there is a very high ceiling, the lights may be placed above the heads of the audience if they can be placed entirely out of the range of vision.

Another good example of this idea of lighting is found in the Illinois Theater in Chicago. Here all lights which come within the range of vision are protected by shades or, in some cases, by strings of prismatic beads.

But, some one may object, will not this new scheme of lighting be very expensive? Is it not true that the intensity of the light varies inversely as the square of the distance? And by confining yourself to the idea of concealed lighting, are you not losing the benefit of the economical distribution of light? This may all be true, but the question is not altogether one of economical distribution. A man who pays five hundred dollars for a Kermanshah rug does not make the purchase primarily for the purpose of securing the most economical method of carpeting his floor; it is to secure an artistic result. In like manner we have arrived at a point where we must think of something besides economy in the arrangement and distribution of our lighting.

A few years ago a prominent south side hotel was wired for electricity. One outlet was provided for each room. To-day such an arrangement would not be thought of for a moment.

In the early days of electric lighting the ordinary sixteen candle-power incandescent lamp took about four watts per candle-power of illumination. An ordinary 16 candle-power lamp now requires 3.1 watts per candle and many of the newer types of lamps require but 2½ watts per candle. The new metal filament lamps

RAILWAY EXCHANGE.

made of tungsten and similar material will probably cut this relative consumption in two. At the same time the price for electricity is also being reduced in a rapid ratio. We can therefore afford to provide means for properly diffusing the rays of light, even if the operation does sometimes mean a reduction in illuminating efficiency.

The third standpoint from which we may view the subject of illuminating engineering is from the practical standpoint of vision.

In the transaction of business throughout a great city artificial light is a necessity, in a great many places, during the day time, and in all places where business is carried on at night.

The question that presents itself to the illuminating engineer is, what methods are best adapted for practical illumination, so that objects may be seen and handled with facility? In viewing the subject from this standpoint, some will say that the arguments are all against the use of diffused and concealed lighting, yet even from an economic standpoint, there is much to be said in its favor.

Take for instance the matter of lighting windows. A few years ago window lighting was done for the most part by lights placed on brackets or studded around the windows. The bare unshaded lamps were plainly visible and the effect of the illumination was that of a bright glare of light, the principal thing which impressed itself upon the beholder being the dazzling effect of the lights themselves. To-day all this is being changed. In the finest stores no window lighting is visible, the lights being concealed, for the most part, at the top of the window and the lights are so placed that the illumination may be cast, by means of reflectors, directly on the goods

ORCHESTRA HALL.

themselves. The result is a soft and pleasing effect very attractive to the would-be purchaser. At the same time a less number of lights is required, so that the actual cost of the window illumination is less than one-half of what it was before.

A prominent merchant, owning one of the largest stores on State street, recently told the writer that he was planning to take out all his window lights which were installed on the old scheme and have his windows wired according to the new plan. He said, "The trouble is, the customers see the lights and not the goods," and that is not what the merchant is striving for.

We all know that the effect of an intense light is to cause the pupil of the eye to contract and reduce the power of seeing objects less brilliantly illuminated. There are some towns which try to light their streets by a few extremely brilliant arc lamps placed at long distances apart and the result is that in those parts of the streets which are in shadow, the difficulty of seeing is increased. While this is an extreme case, it simply illustrates the fact that a moderate degree of light well distributed is much better for the purpose of vision than occasional spots of intense brilliancy.

The amount of light required for practical illumination has always been a matter of some controversy. The tendency of the times, however, is to increase the number of lights, but to provide them with additional shades and diffusing devices. In this connection it may be interesting to note some data which was collected by Mr. J. H. Goehst for a paper which he delivered before the employees of the Chicago Edison Company about six years ago. This data is based on the average conditions as they existed here

SHOW WINDOWS, WOLF CLOTHING CO.

in Chicago at that time. He figures that for first-class lighting in a store where decorations are light, there should be one sixteen candle-power lamp to each 500 cubic feet; where the decorations are darker, one sixteen candle-power lamp to every 400 cubic feet. In window light reflectors one sixteen candle-power lamp for each eighteen inches in length in small windows about eight feet in height. For large windows twelve to fifteen feet in height the lamps should be spaced about ten inches apart. Office lighting is figured at about one sixteen candle-power lamp for every eighty square feet of floor space for general illumination and each desk should have its own lamp in addition.

From data taken in a number of theaters here in Chicago the average is found to be about one sixteen candle-power lamp to each six hundred cubic feet for the lighting of the auditorium itself. In the lighting of offices a good many have favored the use of large lamps placed on the ceiling of the room and the doing away of desk lamps altogether. For this purpose clusters of the new Meridian lamps, and also the Nernst lamps have been used to a considerable extent, both in stores and in offices. For large stores, if suitable shades are used, this is probably the best method of lighting thus far introduced, as it places the majority of the lights out of the field of vision; but for offices, it is not, in the opinion of the writer, entirely advisable. While the lights are not in the direct line of vision yet in a large office where the ceilings are of moderate height the lights are low enough to be more or less in the eyes during conversation and although the eyes may not be directed at the lights a considerable amount of light enters the eye at an unusual angle and this is

WINDOW, CARSON PIERIE SCOTT & CO.

injurious to any but very strong eyes.

The best scheme for office lighting would be to have the lights for general illumination placed near the ceiling and covered by prismatic shades, while at each desk should be placed a frosted lamp so shaded as to be entirely concealed from the eye and so placed that the light will come from the left-hand side of the desk. With this arrangement the light will not be reflected directly in the eyes from the paper and at the same time there will be no shadow from the hand to interfere with writing.

When a large amount of general lighting is necessary, the mercury-vapor lamps are to be used very largely on account of the greater area of illuminating source, thus giving a softened and more diffused light.

The Federal building in Chicago, which, as a building, is one of our best exponents of good lighting, has installed a number of these mercury-vapor lamps and with fairly satisfactory results.

In conclusion we would say that the limits of such a short article as this makes it possible only barely to touch on the more salient features of illuminating engineering, but we have endeavored to bring out the following points:

1st. The need of scientific illumination from a physiological standpoint, from a decorative and esthetic standpoint, and from the standpoint of vision.

2nd. We have shown that a beginning has already been made in this direction. While it is true that in nine hundred and ninety-nine cases out of every thousand our lighting is very crude and very improper, we are at least beginning to get some idea on this subject and there is no question but what the next twenty-five years will see a wonderful advance along this line.

Probably no other need is more imperative than that of a perfect system of illumination and as surely as necessity is the mother of invention, so surely will the day come when our systems of lighting will conform to the higher requirements of a more advanced civilization.

The Fixture Installation of the State Capital at Harrisburgh Pa.

FIG. I.—ROTUNDA.

The fixture installation of the Pennsylvania State capitol, which was formally opened in October of this year, is in several respects the most remarkable installation in America. In the first place, it is undoubtedly the most expensive set of fixtures ever put into a building of any kind. The contract price for the fixtures alone was $2,000,000. So elaborate and expensive has been the furnishing of the building in general that it was aired as a public scandal, and was an issue in the recent state election.

To carry out the ideas of the public officials having the matter in charge, who were evidently determined to have all furnishings and equipments of the finest quality that money could buy, required the use of unusual methods. A company was organized for the sole purpose of manufacturing the lighting fixtures, in order that exclusive attention might be given their execution, and the highest degree of talent, both in design and workmanship, might be used. All of the fixtures are of cast bronze, hand-chased by the most skillful artisans obtainable. The original designs were, as would be expected, elaborate in detail, and required unusual skill in casting. In fact, there are but few artisans in the country who are capable of turning

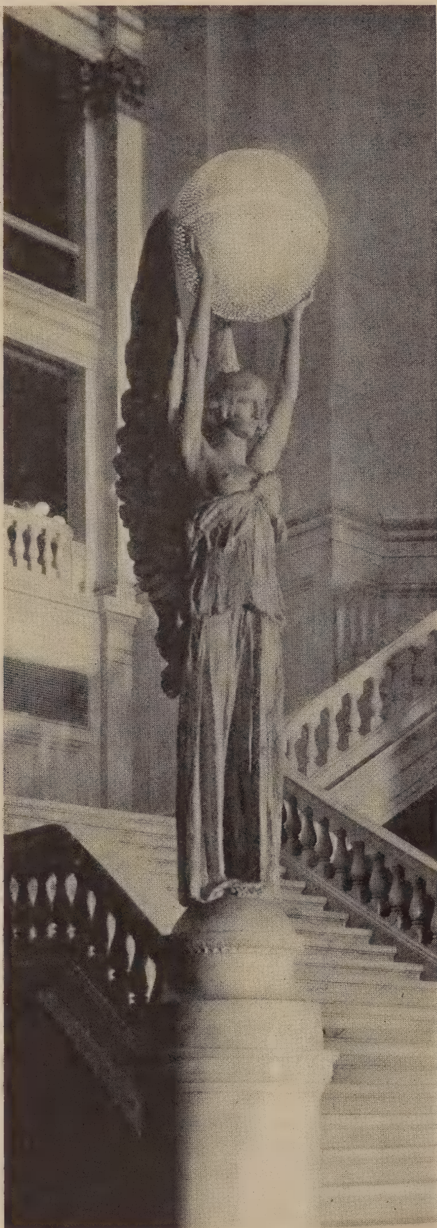


FIG. 2.—NEWEL POST STANDARD, GRAND STAIRWAY.

out work of this character; and it is claimed that there was not a manufacturer who could have completed the work in the time specified in the contract, and executed it with the requisite degree of excellence. As specimens of art metal work in bronze it is probable that there is not another collection of fixtures in any building in the world which can equal them.

As to the propriety of expending such an amount of money on the material and elaboration of detail of lighting fixtures, that is another story; but an inspection of the fixtures, even by one unskilled in art metal work, will show that those responsible for their purchase should at least be credited with having secured what they evidently sought, namely, the most perfectly designed and built, as well as the most expensive, fixtures that it was possible to obtain.

The illuminating results obtained in this case are also a matter for separate consideration, and for which the makers of the fixtures are in no wise responsible, since their sole duty was to execute the order of their customer to the best of their ability.

A general idea of the magnificent scale upon which the fixtures are designed may be gained from the illustrations given; but it is impossible to show in these small views the elaborate detail of design, which has been wrought out with the utmost care, even to the minutest detail.

Fig. 1 is a view in the main rotunda, showing the general disposition of the lighting fixtures, which are in the form of standards, or large candelabra. The general method of lighting the corridors may also be seen at the top of the illustration, where three of the ceiling fixtures used for this purpose are shown; the finish of this corridor is white marble. Fig. 2 shows the newel post fixture, the location of which is also shown in Fig. 1. The size may be judged by comparison with the steps.

Fig. 3 shows a portion of the interior of the Assembly Chamber. The ceiling fixtures here are in the form of huge lanterns—or perhaps "lighthouses" would be a more befitting term. They are, beyond doubt, the heaviest lighting fixtures ever made.

FIG. 3.—ASSEMBLY CHAMBER.

FIG. 4.—SENATE CHAMBER.

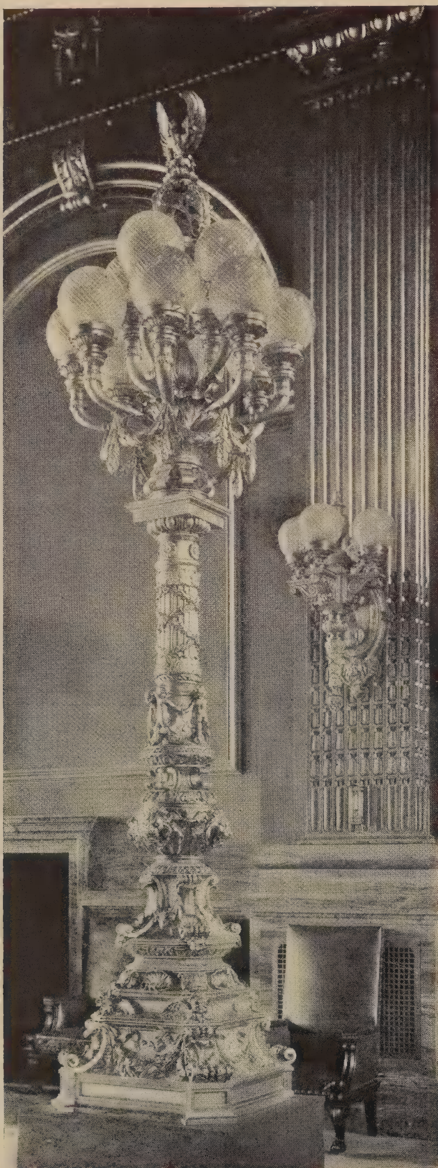


FIG. 5.—CANDELABRUM, SENATE CHAMBER.

As will be seen, a person could easily stand up inside these lanterns. It may be mentioned here, than when the fixtures were being put in place throughout the building a temporary traveling crane was erected for the purpose of handling them. The decorations in this room are best described by the word "gorgeous;" the ceiling being gilded, and the finish of the walls and draperies dark blue.

Fig. 4 is a view of the Senate chamber, showing the arrangement of ceiling fixtures and position of side brackets. Although these fixtures are less massive, their design is most elaborate in detail, and the workmanship exquisite in its perfection. The ceiling is gilded, and the furnishings are of dark green. Fig. 5 shows one of the standards which are placed on either side of the rostrum. The magnificence of this fixture may be judged by comparing it in size with the chair, and also by an inspection of Fig. 4. Fig. 5 also shows one of the exquisitely wrought side brackets, with which each of the pilasters is finished.

Fig. 6 is the private office of the Secretary of the Commonwealth, and shows the type of fixtures used to a considerable extent in the various offices in the building. It will be noted that the table lamp is supplied with current by a flexible cord dropped from the chandelier—a make-shift arrangement entirely out of keeping with the general magnificence of the surroundings.

Fig. 7 shows the Attorney-General's private office, and illustrates another type of fixture which is also quite largely used in the various offices. The table lamp with flexible cord extending to the chandelier is also in evidence in this room.

Fig. 8 shows one of the general office rooms, illustrating another type of fixture which is generally used for the various counting rooms. A feature of this installation well worth noting is the side brackets. The side walls are equipped with metallic filing cabinets on all sides, and in order not to displace the brackets a blank space is left in the middle of the filing case, and the bracket brought forward to the face of the cabinet.

Fig. 9 shows a standard in the Governor's reception room, and gives a fair idea of the elaborate detail characteristic of the entire installation.

FIG. 6.—PRIVATE OFFICE, SECRETARY OF THE COMMONWEALTH.

FIG. 7.—PRIVATE OFFICE, ATTORNEY GENERAL.

FIG. 8.—GENERAL OFFICE, STATE DEP'T.

The glassware with which the fixtures are equipped was made especially for this installation, and the same general remarks will apply as in the case of the fixtures; namely, as pieces of artistic glass they are of the highest order. Most of the globes and shades are of crystal glass, beautifully cut; the others have an etched finish, giving them a satiny, translucent effect. The glassware was all made by the Phoenix Glass Company.

The general management of the company which manufactured this remarkable installation was Mr. C. F. Kinsman, of New York.

The public is somewhat hard to please in matters of government expenditure. When the New York State capitol building was being constructed, it was found necessary to replace the oak ceiling in the Assembly chamber not long after it had been completed. It was discovered after the new ceiling had been up that *papier maché* had been substituted for oak in the panels; the architect declaring that this substance was far more durable and suitable for the purpose, and being so far above the line of vision, could not possibly be distinguished from real wood. This explanation, however, failed to satisfy the public, or at least that part of it that comprised the opposition political party, and a general "howl" was made at the substitution of the base material. The public, in general, have but little idea of the extent to which gilded wood and plaster are being used in the place of solid bronze in the construction of fixtures and other art metal work. Modern electroplating processes have enormously ex-

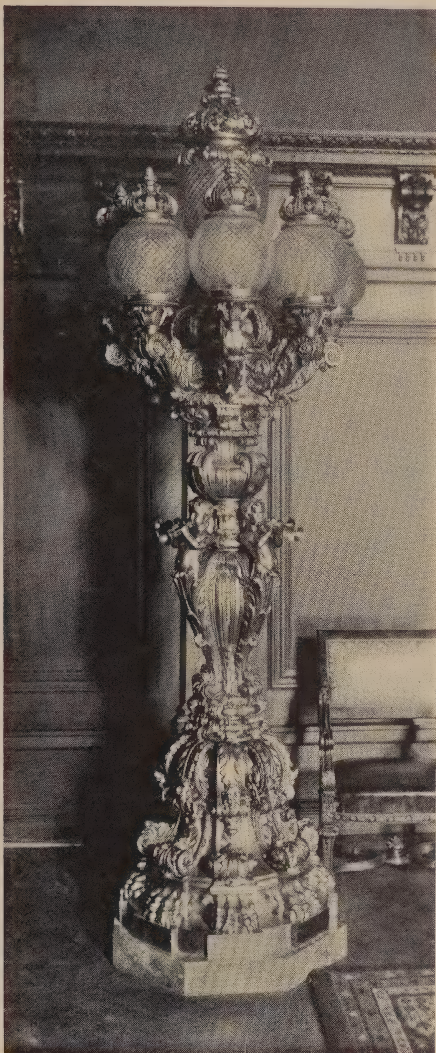


FIG. 9.—STANDARD IN GOVERNOR'S RECEPTION ROOM.

tended the possibilities of such imitation. In the case of the fixtures that we have just described, all imitation and substitution have been rigorously excluded; the fixtures are genuine, both in material and workmanship, throughout; but in this case public clamor has arisen because their representatives have paid the price of the genuine, and the best that could be obtained. It would seem that he who deals with the public must expect abuse.

As we have stated before, a consideration of this installation from an illuminating engineering standpoint brings us to an entirely different set of conclusions, the summing up of which would be, that as an example of the complete subversion of the purpose and aims of illuminating engineering to the desire to make an impression by the sheer display of expensiveness, the case is without a parallel in history. We hope in a future issue to treat more fully of the illuminating results obtained.

The point has been made by critics of fixture design that the weight and strength of the fixture should be actually and apparently sufficient to support the lamps and shades, but that any obvious excess in massiveness beyond this is contrary to the first principles of aesthetics as applied to decorative art. In the present instance, this excessive weight of metal has been carried apparently to the utmost limit. The weight of the fixtures in the assembly chamber, for example, must run into the tons, and all this to support a few electric lamps which any errand boy could easily carry in a basket! The same general criticism holds in regard to all the fixtures in the installation. In fact the whole installation may be more properly classed as art metal work than as lighting devices.

Plain Talks on Illuminating Engineering

By E. L. Elliott.

III.—MEASUREMENTS OF ILLUMINATION ON A GIVEN SURFACE—THE EYE AND VISION

The unit of intensity of illumination commonly used in this country is the "foot candle," which we have already defined as the intensity produced upon a surface one foot from a standard flame so placed that the horizontal rays strike the surface perpendicularly. Illumination produced by rays striking a surface perpendicularly is often briefly called "normal" illumination, "normal" being a synonym in this case for perpendicular.

In determining the intensity of illumination on any given surface from a light source in a given position there are two factors to be considered; first, the distance of the surface from the source, and second, the angle which the surface makes with the rays striking it. An example will best illustrate the methods to be used in determining the results. In Fig. 1, let us suppose a light source placed at L, and let A-B represent a surface below this source. Let us first suppose that the light-source is one foot above the surface: it would produce an illumination of one foot-candle; at two feet the illumination would be one-fourth as great (law of inverse squares) that is ¼ foot-candle; at three feet it would be 1-9 of a foot-candle; and so on for any given distance. If, however, our light source had a vertical intensity of 5 candle-power, then the intensities at these given distances would be five times as great. It will be seen from these examples that the intensity of illumination on a surface at any given distance from a light-source may be found by dividing the candle-power intensity of the rays striking the surface by the square of the distance of the surface from the source. Thus, if the intensity is 5 candle-power, and the distance is 6 ft. the intensity of illumination will be 5-36 of a foot-candle.

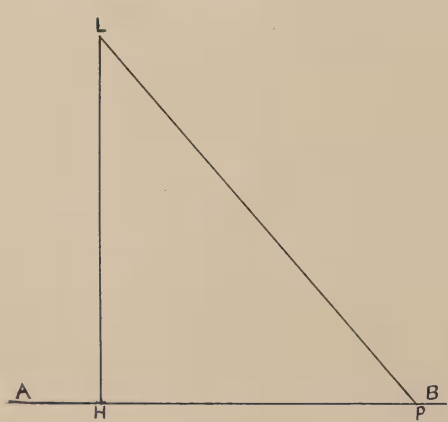


FIG. 1.

Now suppose that we want to find the illumination on a given surface at some point not directly underneath the lamp, as at P. The known quantities which we have given in such cases are generally the perpendicular height of the source above the surface L-H, and either the distance of the point P from the foot of this perpendicular, or the angle *a,* which the line L-P makes with the perpendicular, and the intensity of the light rays at this angle, that is, in the direction L-P. We have then to find out the distance from the light to the given point, L-P, and use this in connection with the difference which results from the rays falling upon the surface at an agle. Both of these unknown quantities can be found by a mathematical process from the known distance, L-H, and the angle *a.* If the distance H-P is known instead of the angle *a,* the angle may be easily found by drawing the figure to scale and measuring the angle with a protractor. From these known quan-

tities, i.e., the height L-H, and the angle *a*, the illumination at the point P may be found by means of trigonometry. By the use of the following table, which has been worked out according to the formula for different angles, we can solve the problem very easily by the use of simple arithmetic.

Angle.	Reduction Factor.	Angle.	Reduction Factor.
1	1.000	37	.509
2	.998	38	.489
3	.998	39	.469
4	.993	40	.449
5	.988	41	.429
6	.983	42	.410
7	.978	43	.391
8	.971	44	.372
9	.963	45	.353
10	.955	46	.335
11	.945	47	.317
12	.935	48	.300
13	.925	49	.282
14	.913	50	.265
15	.901	51	.249
16	.888	52	.233
17	.874	53	.218
18	.860	54	.203
19	.845	55	.189
20	.829	56	.175
21	.813	57	.161
22	.797	58	.149
23	.780	59	.137
24	.762	60	.125
25	.744	61	.114
26	.726	62	.103
27	.707	63	.0936
28	.688	64	.0842
29	.668	65	.0754
30	.649	66	.0671
31	.630	67	.0596
32	.610	68	.0526
33	.590	69	.0460
34	.570	70	.0400
35	.550	71	.0345
36	.529	72	.0295

The left-hand column in the table gives the angles up to 72° and the right-hand column the corresponding reduction factor to be used in obtaining the desired result. Let us suppose that the angle *a* is 30°, and that the intensity of light at this angle (taken from the curve of distribution) is 10 candle-power, and that the height LH of the source above the surface is 6 ft. From the table we find that the reduction factor for 30° is .65. We then square the height, which gives 36, and multiply the result by the factor .65, which gives 23.4. The candle-power intensity 10 divided by this product then gives us the result required: $\frac{10}{24.3} = .43$. The rule for using the table is therefore as follows: Multiply the square of the height of the light source by the reduction factor corresponding to the given angle, and divide the candle-power intensity of rays at this angle by the product thus obtained; the result will be the foot-candle illumination on the horizontal surface at the given point.

This rule enables us to determine the intensity of illumination at any point on a horizontal plane below a light-source, providing we know the height of the light source above the surface, and its distribution curve. If more than one light source is used, it is simply a question of determining the illumination from each source separately at the given point and adding the results.

Of the one remaining measurement, namely, the brightness of the image on the retina of the eye, there is but one point of importance to be remembered, and that is, that the brightness of the image does not decrease with the distance. There is a law in regard to the formation of images by convex lenses, which exactly counterbalances the law of inverse squares; so that instead of varying inversely as the square of the distance, as in the case of light, the brightness of the image on the eye does not vary at all. The practical application of this is found in the fact that the glare produced by a light-source does not diminish by distance as the illumination diminishes. This subject will be better understood after the reader has followed the explanation of the eye and its use.

THE EYE AND VISION

Vision is the effect produced upon the brain by the agency of light, acting through and upon certain organs especially constituted for the purpose. These organs consist of two quite dis-

tinct parts, viz: the optical part, which directly receives the light, and which is commonly called the Eye, and a certain particular portion of the brain, called the "Optic Lobes." The two parts are connected by nerves, which form the means of intercommunication.

The Eye, as before stated, is an optical instrument, and as such is not difficult to understand. It is identical in principle with the simplest form of photographic camera; and as the camera is such a familiar instrument at the present time, we can perhaps explain the construction of the eye most easily by showing its correspondence with the camera.

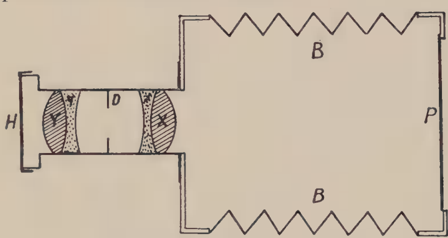


FIG. 2.

Fig. 2 represents a section through the Photographic Camera and Fig. 3, a similar section through the eye. The camera consists of a converging lens, X Y; a diaphragm, or "stop," D; a Shutter or Hood, H; a sensitive plate, P; and a light-excluding box BB, which has the lens and sensitive plate at opposite sides. The lens in the better form of instruments consists of four pieces of glass arranged in two pairs, Xx, Yy, between which is placed the Stop. Each pair of lenses consists of two parts made of glass of different degrees of hardness and consequently different powers of refraction. The entire inner surface of the containing parts is made dead black so as to absorb all light reflected from the sensitive plate. The Sensitive Plate is so arranged that the distance between it and the lens can be varied so as to bring it into focus with objects at varying distances from the camera. The entire instrument is usually placed upon a stand or tripod which permits

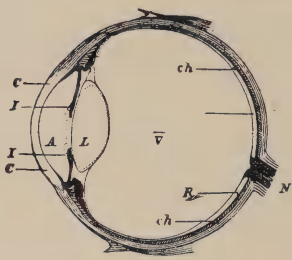


FIG. 3.

of its being directed to any desired object.

Referring to Fig. 3, it will be seen that all the elements of the camera just described are present in the eye. The lens, which is of the converging type, consists of three parts; 1st, the outer part or Cornea, C; 2nd, the crystaline lens, L; and 3rd, a transparent fluid which fills the intervening space, A. Between the Cornea and the Lens is placed the Stop, called the "Iris," I. Back of the Lens is the Retina, R, upon which the image falls, and which is sensitive to light. The Lens and Retina are held in their proper position by an enclosing box which is practically spherical in form, commonly called the eye-ball. This is lined on the inner surface with a dead black substance ch. In order that this enclosing chamber may keep its proper form, it is filled with a transparent, jelly-like liquid. The eye-ball rests in a spherical cavity in the skull which allows it to be moved in all directions so as to bring any desired object into the range of vision, just as the camera is swung around on its tripod. The front of the socket is provided with curtains for shutting out the light, commonly called eye-lids.

The eye and camera differ in their focusing arrangements. The lens of the eye is elastic, and is provided with a set of muscles surrounding it, which, by contraction, cause the lens to bulge out at the center, thus increasing its curvature and consequently shortening its focus.

The eyelid differs in one very important respect from the shutter of the camera; it does not entirely shut out

the light, but is quite translucent. The difference between light and darkness can be very readily detected with the lids closed, showing that considerable light passes through the lids.

The retina of the eye is thickly strewn with nerve fibres, which unite, as the separate wires of telephone cables unite, and pass to the optic lobes of the brain. The image formed by the lens of the eye falls upon the exposed ends of these nerve fibres, and the action of the light produces a stimulation upon them, which, being transmitted to the brain through the optic nerve, produces the sensation of vision.

Certain rays which do not produce the sensation of vision, such as the heat, or infra-red rays, and the actinic, or ultra-violet rays, act upon the organs of vision, producing an effect that is harmful in proportion to its intensity. The ultra-violet rays in particular may readily produce most serious results; hence light-sources containing an excess of violet and ultra-violet rays are to be avoided, especially for use where close attention of the eyes is required. The rays that produce the highest illuminating effect, that is, which most powerfully effect the nerves and optic lobes of the brain, are those of the yellow and yellowish-green color. Such rays, however, in too great an excess, are also injurious, as in fact is any light which is even approximately monochromatic.

The mental impression called vision includes the following elements: (1) contour; (2) relief; (3) perspective; (4) color.

Contour includes the boundary lines of objects, and all details that do not embody the other three elements, such as printing and writing, and all other cases in which the impression is wholly due to lines on a flat surface.

Relief is the result of varying intensities of light, commonly known as "light and shade." The effect of relief is also materially strengthened by the joint action of the two eyes (binocular vision). The simplest illustration is that of a ball or sphere; as is well known it is impossible to produce the spherical effect without differences in light and shade. A sphere that is equally illuminated appears a flat disc, as in the case of the moon at full.

Perspective arises from the varying visual angles subtended by objects and different distances, and is also aided by binocular vision.

Color is simply a difference in the quality of the light, and not an essential element of vision. "In the night, all cats are gray," but the general appearance of the cat is the same as that produced by daylight. In fact, color may be considered as a purely decorative feature thrown in by nature to heighten the visual effect and relieve the monotony. Object which we are accustomed to see in colors may be very satisfactorily reproduced by simple differences of light and shade; for example, in a portrait of a person, if well executed in black and white, we hardly miss the absence of the effect of color. The power to discriminate between colors also varies greatly with the individual, in some cases being almost absent. "Color blindness," as this defect in vision is called, is of very common occurrence.

The analogy between the photographic camera and the eye applies with equal force to their use and misuse; so that we may profitably consider some of the cases of defective photographs, with a view of determining the corresponding conditions of unsatisfactory vision.

In general those conditions which will produce a satisfactory negative in the camera will produce equally satisfactory vision; and whatever will impair the quality of the "negative" will likewise impair the visual effect.

It will be instructive to consider some of the causes of defective photographic negatives, and see how the same causes operate to produce unsatisfactory visual effects.

Insufficient illumination: This produces a hard negative; that is, the shadows are lacking in details, and the

high lights, by contrast, too sharp. To remedy it, use a larger stop, and make a longer exposure. These remedies for insufficient illumination the eye endeavors to apply automatically. The Iris is distended to its fullest diameter and a greater length of time is required before the brain can "develop" the picture. It has been verified by actual experiment that the number of words one will read per minute varies with the brilliancy of illumination. Injury to the eyes from too dim a light is undoubtedly due to injury to the nerves in their effort to "develop" the image, i. e., to produce the sensation of vision from the effect of the image on the retina; it is a case of "forced development." Such injury, however, is far less liable to occur than injury from other causes which we shall consider later.

Too Strong Illumination: This produces a "flat" or "foggy" negative, the familiar results of "overexposure." The remedy: use a smaller stop, and shorter exposure. As in the former case, the eyes attempt to do this automatically. The Iris is contracted to its smallest diameter, and the continued strain of the muscles in doing this produces the "squinting" expression and fatigue, familiar to all who have read under a too brilliant light. To shorten the exposure, the eyelids frequently close momentarily, or "wink and blink." Frequent closing of the lids is a sure sign of visual fatigue. Some experimenters have attempted to measure the effectiveness of different methods of illumination by counting the number of times per minute the user would unconsciously wink. When both these remedies are used to their limit, i. e., the Iris closed to its smallest diameter, and the light shut out, as frequently as possible, by closing the lids, and still the light falling on the retina is too strong, then the inevitable must follow—a "foggy plate," i. e., blurred vision, which, if continued long enough, will seriously affect the ability of the retina to produce a clear image. Injuries from too strong light are much more likely to occur than from too little light; but by constant exposure to too strong light, it may become permanently injured for use with both strong and dim light.

Light shining into the camera: This produces the well-known effect called "halation," so often produced in photographing interiors where the camera is pointed toward a window. In vision this is called "glare" and "irradiation." There is no remedy in either case except to remove the cause, that is, to see that no light enters the eye or camera that has not been first reflected from some object; in other words, keep the light-source out of the direct range of vision; or if this is impracticable, use some kind of diffusing globe so as to reduce the glare as much as possible.

Some years ago the Surgeon-General of the United States Army, in one of his official reports, stated that the eyes of the marines were suffering very much from the effects of the electric lights in their quarters on board ship and recommended that steps be taken to prevent further serious defects, but did not state what these steps should be. The ceilings of the sailors' quarters are necessarily very low, and an incandescent lamp placed in any position would necessarily shine directly in the eyes of the occupants of the quarters. A diffusing globe or frosted lamp would probably have been thought a great waste, both of the light and the money required to purchase it. While a diffusing globe would have cut down the actual quantity of light more or less, the illumination produced would have been practically free from the serious results to which the officers' attention was called.

Light coming from the wrong direction: This may produce various defects. If the object seen or photographed is a plain surface, and the light falls upon it at such an angle that the direct reflection can enter the lens, the details of the surface will be

lost or destroyed. Anyone who has attempted to make a photographic copy of another photograph will be familiar with this effect. If the copy is put up so that the light falling upon it is reflected into the camera as from a mirror, the grain of the paper will be brought out so strongly as to almost obliterate the details of the picture itself. Those who make a specialty of photographic copying, as for example, photo-engravers, always place their light-source, which is usually from an arc-lamp, at a large angle with the "copy," so that the direct reflection falls past the camera, and leaves only diffuse reflection to form the image. Precisely the same results will follow the same conditions in vision. In writing, drawing, etc., the light should always strike the paper at a large angle, and never so that the direct or specular reflection will enter the eye.

For this reason a light placed very high is usually bad, since it is impossible to get rid of the direct reflection. The best position is at about the level of the eye, at the left, with a shade to prevent any direct light from the source entering the eye.

By the use of a good reflector it is possible to place electric lamps on the ceiling and still produce a sufficiently brilliant illumination at the ordinary height of the table; but while this arrangement is very satisfactory for general illumination, it is quite unsatisfactory for special illumination.

There is an additional physiological reason why strong illumination from above is fatiguing to the eye, viz.: that it falls upon that portion of the retina which is unaccustomed to strong light. The eye had adapted itself to the conditions of daylight illumination, and this is always from a moderate elevation. Those working indoors receive the light through windows which are usually curtained off at the upper portion, so that the strongest light comes in not far above the level of the eye, in a standing position; while out of doors the eye is protected from the light coming from the higher elevations by the hat brim. Those who are accustomed to indoor light, however, find the full light out of doors, especially in bright sunshine, very trying to the eyes.

The most familiar example of the injurious effect of light coming from unusual directions is that of snowblindness. This is due to reflection from the surface of the snow giving a very strong light from below. Where it is necessary to work under a strong light from a high elevation the eyes should be protected by an eye-shade in such a manner as to cut off the direct rays; for the strong light from above is simply a reversal of the conditions which produce snowblindness.

Light from two or more directions: This in photography would produce a "flat" picture, that is, one lacking in perspective or relief. The best illumination requires the strongest light from one particular direction, but some light from every direction. This is the condition when daylight is admitted through a large window. If the object looked at, however, has a perfectly flat surface, then it does not matter from how many directions the light comes; since there is no relief in the object looked at, but only a contrast between black and white. But where the object is not a plain surface, as in the case of various sorts of work, then light from all sides destroys the relief and renders the vision more difficult.

Simple Studies in Fixture Design

By Ernest C. White.

It is not the purpose of these articles to go into the elaborate details of fixture design either from the standpoint of mechanical construction or the calculation of illumination. It is intended, however, to offer suggestions which will be both practical and in line with the best illuminating engineering practice.

It is believed that with the co-operation of fixture manufacturers, designs may be produced which, whether ornate or simple, are at least evolved from first necessities. If we are to go on making fixtures first, and then selecting glass ware to "look well" on the fixture we shall make slow progress towards better illumination. It seems far more reasonable to start from the assumption that certain lamps and glassware in certain positions are required and then design a fixture on which these necessary "accessories" are to be carried.

Many forms of glassware are becoming recognized as efficient for illuminating purposes in a general way. Even where this efficiency is recognized, however, there is still much reluctance to the use of efficient reflectors because of objections from an artistic standpoint. The first principles of lighting fixture design, as above referred to, must be depended upon to overcome the natural antipathy to incongruous combinations of fixtures and glassware.

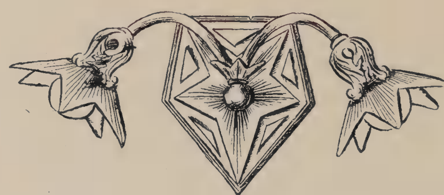


FIG. 2.

Fig. 1 shows a five light chandelier of no more expensive design than many in common use. The difference lies in the fact that this fixture is intended to carry a five-pointed prismatic glass reflector, which combines

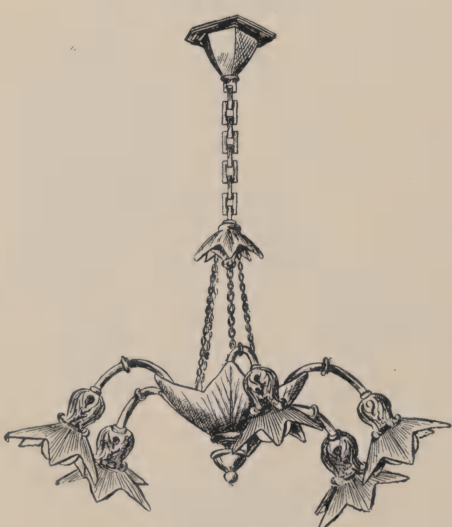


FIG. 1.

FIG. 3.

a reasonably high efficiency with enough peculiarity of form to establish some artistic relation between the fixture and reflectors. Spherical frosted lamps are used as these are fairly exposed to view in all directions.

Fig. 2 suggests a possible way of utilizing the same glassware on a two light bracket.

Fig. 3 is a large ceiling fixture carrying out the very conventional combination of a large central globe surrounded with smaller lights. In this case the upper half of the central globe, however, is a prismatic reflector, and the lower half a Holophane bowl. This would contain about four lights. The surrounding balls are made on the same principle as the globe shown in Fig. 4, except that the lower ground glass half is ornamented without stars. It must be said that this fixture is very little more than a grouping of efficient glassware. The general appearance, however, is not inharmonious, while the general efficiency as a ceiling cluster is certainly considerably above the average.

Fig. 4 suggests only one out of a hundred ways in which the glass reflector illustrated could be suspended without artistic offense. Yet this piece of glassware is exceedingly plain as seen by itself, it being one of the latest forms of globes made in one piece, the upper half being composed of reflecting prisms, and the lower half of heavily frosted glass.

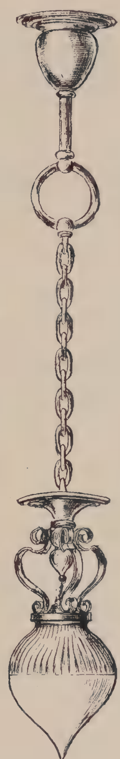


FIG. 4.

Some Difficulties in Street Photometry

By J. S. Dow

It is only recently that the public has come to feel much confidence in photometrical measurements. Tests in the photometrical laboratory, however great their experimental value, frequently do not give any adequate idea of what the results of using a given system of illumination under practical conditions, will be.

There are so many factors, such as the grouping of the lamps, the reflecting power of the wallpaper, etc., to be taken into account, and it is only recently that the influence of these factors has been studied by means of measurements made on the spot.

There are, however, many difficulties in making accurate measurements of this kind even at the illuminations which are commonly used for indoor lighting, and when we come to street-lighting, the difficulties are multiplied. Measurements have usually to be made over a wide area. The illuminometer must therefore be portable, and this in itself entails a considerably lower degree of accuracy than that obtainable in the photometer room. Moreover, the degree of illumination to be measured is often extremely low, and this makes it very difficult to take satisfactory photometrical readings. Mr. Haydn Harrison in a recent paper before the English institution of electrical engineers gave figures ranging from 0.05 candle-feet down to 0.005 candle-feet for the *minimum* illumination met with in the

streets of an ordinary English town.

The acuteness of vision curves given by Dr. Bell in THE ILLUMINATING ENGINEER for June show very clearly how rapidly the factor $\frac{d\,I}{I}$ —the smallest percentage change of illumination detectable by the eye— increases when the illumination falls below about 0.2 foot-candles.

In addition to this we have to face the fact that small as these illuminations as measured by a photometer are, they are certainly very much greater than the actual illumination of the pavement or roadway which reflects a variable and often very small fraction of the light impigning upon it. In this way a source of uncertainty is introduced which photometrical measurements do not take into account, and these measurements are therefore of a somewhat arbitrary character. It is not, in fact, quite settled whether such measurements should be made in a vertical plane, a horizontal plane or a plane at 45° to the horizontal. All three methods have been used by different investigators.

The most serious difficulty, however, arises from the different colors of many lights such as flame arcs, incandescent gas lamps and mercury vapor lamps, which have recently been introduced. Apart from the difficulty of making a judgment at all for lights of such different colors a photometrical measurement may easily give quite a different impression to that received by the eye when surfaces of a different size and character to the photometrical surfaces have to be illuminated.

It may be well in this connection to briefly repeat the physiological theory of the "rods" and "cones" as quoted by the writer in a recent paper. (ILLUMINATING ENGINEER, September, 1906). According to modern physiological views the perception of light and color is accomplished by minute organs scattered over the retina and known as the rods and cones. The rods can perceive light only but cannot distinguish color. They are, however, most sensitive to bluish light, which appears to them white. They are sensitive to very weak light but soon become "saturated" and do not respond further to increased illumination past a certain point. The "cones," on the other hand, can appreciate difference of color. They are unsensitive to weak illuminations, but when the illumination is increased past a certain point they suddenly begin to act and continue to respond to stronger light until, at ordinary illuminations, the action of the rods is insignificant in comparison. The cones are most sensitive to yellow light.

The result of this is that very peculiar effects occur when the illumination is reduced to the borderland where the action of the rods is comparable to that of the cones. At the illuminations of the order frequently met with in street-lighting, the Purkinge effect becomes very noticeable. In fact at such illuminations the eye may become practically blind to red light. Consequently curves of illumination calculated theoretically from the candle-power possessed by a lamp at strong illumination may prove quite misleading.

Even results obtained with a photometer on the spot may not furnish a correct idea of the actual illumination, and for the following reason. At the central portion of the retina there exist only cones while both rods and cones are to be found on the surrounding portion. Consequently at weak illuminations the apparent brightness of the illumination depends very greatly on the portion of the retina on which the image of the illuminating surface falls. Even for white light, the illumination depends on the size of the illuminated surface, while for lights of different colors the differences so introduced may be very great indeed.

The comparison of the small illuminated surfaces in the photometer, therefore, cannot give a correct impression of the actual illumination of large tracts of pavement or roadway.

We have also to remember that the

main object of street lighting is to enable us to see our way about satisfactorily—to see clearly, for instance, where the pavement ends and the roadway begins—in fact to reveal detail.

Now according to Helmholtz, Weber and others, at weak illuminations the detail revealing power of red light is better, for a given intensity of illumination, than green light. It seems possible, therefore, that photometers depending on the "method of equal brightness" are open to objections from this point of view.

Finally it must be remembered that the personal element is admittedly very important when we are dealing with color and when the illumination is very low.

Fortunately it seems probable that the progress which is being made in illuminating matters will certainly smooth away many of these photometrical difficulties. The acuteness of vision curves already referred to show that while the visual acuity falls off rapidly below about 0.2 candle-feet, no very considerable gain is obtained by increasing the illumination past 1 candle-foot. Probably therefore we shall eventually be able through the greater cheapness of light, to secure a uniform illumination in the neighborhood of this value and so avoid the photometrical consequences of the feeble illumination we have often to be content with at present.

Also it seems likely that a standard spectrum for illuminants, approximating to daylight, will eventually be agreed upon and adopted, and that the color effects which are at present so troublesome will thus be avoided.

Daylight Illumination

By O. H. Basquin.

II. BRIGHTNESS OF THE SKY

In speaking of the candle-power of a lamp, the "candle" which is commonly referred to as the unit is the British sperm candle of 1860, and it is the horizontal radiation from this old candle to which reference is made. Any lamp has one candle-power in any particular direction if its rays in that direction have an effect upon the eye equal to that of the horizontal rays of the standard candle. The eye is a fairly good judge of the equality of two light intensities, but not of ratios much different from unity. In order therefore to compare light sources of different magnitudes, some arrangement must be made to equalize their effects upon the eye, after which their ratio can be inferred from the physical relations adopted. Thus, by varying the distances of two lights from a screen until their effects are equal, the ratio of their candle-powers is commonly inferred from the law of universal squares.

It is rather striking that the candle-power for different individuals of a lamp is not necessarily a constant even if its radiation is constant. This is because candle-power is defined in terms of visual sensation and different eyes have somewhat different degrees of sensibility for light of various colors.

We may imagine a unit candle giving an equal radiation in all directions and placed at the center of an imaginary sphere of one foot radius. The illumination at any point on the surface of this sphere is then said to be one *foot-candle,* frequently written *candle-foot.* The flux or stream of light passing through the whole surface of the sphere is sometimes spoken of as one *spherical-candle.* The area of the sphere is 4 π square feet. The illumination may be defined in another way, namely in terms of spherical candles per square foot, and from the above it is readily seen that one spheri-

cal-candle per square foot is the same illumination as 4 π foot-candles.

A somewhat more dignified system of units than the above has grown up in Germany and is commonly used among scientific men the world over. In this system the standard source of light is the Hefner lamp, much superior to the old-fashioned candle in reliability. Its intensity may be called the *hefner* and is equal to 0.88 candles. Assuming uniform radiation and a sphere of one meter radius about the lamp, the illumination at any point on the spherical surface is called one lux and equals 0.082 foot-candles

$$(0.88 \times \left(\frac{\text{foot}}{\text{meter}}\right)^2 = 0.082).$$

The flux per square meter of the sphere, i.e., per unit solid angle, is called the *lumen* and equals 0.07 spherical candles ($0.88 \div 4\pi = 0.07$).

The *brightness* of a small surface is the ratio of its candle-power at right angles to the surface divided by the area of the surface. It is commonly given in candles per square inch. In dealing with daylight illumination in which the surfaces giving light are of large area and of small brightness as compared with that of artificial lights, it will be convenient to express brightness in candles per square foot. One candle per square foot is the same as $\frac{1}{144}$ candles per square inch and 0.00122 hefners per square centimeter.

It may seem odd that one should express the brightness of the sky on this square foot basis inasmuch as the sky is generally thought of as an intangible far away something rather hard to define and entirely incapable of being estimated in ordinary units. This difficulty disappears with the explanation that the luminous area in question is measured at the opening in the roof or wall through which the sky is viewed. "Per square foot" does not imply that the opening is one square foot in area; it simply comes into the expression for the ratio of the normal candle-power to the area.

A serious attempt to obtain a fairly reliable estimate of the mean brightness of the sky at Chicago was made by the American Luxfer Prism Company in 1897 and I am obliged to this company for permission to report this valuable piece of research. The zenith sky was selected as the most natural point for beginning observations. Its brightness was measured three times daily during about five and one-half days of the week, for nearly two years. In order to make the part of the day covered by these observations correspond fairly well with business hours, it was determined to take them at 9 a. m., at 12:30 p. m., and at 4:30 p. m., and these hours were adhered to throughout.

The photometer room was located on the top floor of the factory building. An opening in the roof between eight and nine feet above the photometer screen permitted the use of apertures of various areas, the sizes generally used being circles of three-inch and five-inch diameters. The illumination from the sky was balanced by that of an incandescent lamp sliding along a horizontal photometer bench. Lamps were at hand of various candle-power, frequently checked at various voltages by means of a Hefner standard lamp.

As the color of the lights to be compared was so different it would have been practically impossible to carry out the observations with any accuracy if the principle of the flicker photometer had not been announced by Professor Rood some time before. The form used was of simple design but proved very satisfactory. The white screen was stationary and made equal angles with the rays from the two sources of light. A rotating sectored disk caused the source of the illumination of this screen to alternate between the lamp and the sky opening. On viewing the screen one saw its brightness flickering if the illumination from the two sources was of different intensity; the lamp was moved until this flickering disappeared. Several settings were made at each observation so that for moderate

values of the brightness of the sky the balance was easily made to within about one per cent. The possible error in the actual value of the brightness of the sky at any observation is naturally greater. It was probably generally within five per cent, which is well within the needs of the present state of the art of illmination by daylight.

The kinds of sky were arbitrarily divided at the beginning into the following five classes, roughly estimated by eye observation:— Class 1, clouds, no blue sky, no sun, storm present or near; Class 2, overcast, no blue; Class 3, clouds predominating, generally cumulus; Class 4, blue predominating —clouds generally cirrus; Class 5, cloudless, either clear blue or hazy.

The results of the observations are given in tables 1, 2, and 3. Classes 1 and 5 give the least light, a result which one might not at first glance expect. In the first class the clouds are too thick for much light to get through while in the last class the atmosphere is too clear to turn much light from its course. The mean brightness of each class of sky is given on each table and it will be noticed that their order of brightness is 1-5-4-3-2 except in the morning observations in which the 4 and 5 are interchanged.

In Figure 1 the classes of sky are arranged in the above order and the mean brightness of each class plotted to the vertical scale. It is very striking that the points representing Classes 1-5-4-3 arrange themselves along a straight line. The difference between 2 and 3 is only half that between the other classes. The light line in Figure 1 suggests approximate and easily remembered values of the brightness of these classes of sky, viz., 200, 300, 400, 500, and 600 candles per square foot. One must not infer from the relation shown in Figure 1 that these classes of sky have mean

Monthly Mean Brightness of Sky at 9.00 a. m.

Table 1.

		Class 1	Class 2	Class 3	Class 4	Class 5	Mean without regard to Class	*	¶
Jan	1898	55	270	266	...	120	210	44	44.3
"	1899	160	180	210	200	120	160	37	....
Feb	1898	360	370	250	...	180	330	43	44.6
"	1899	450	260	430	200	180	240	28	....
Mar	1898	160	440	420	510	230	340	54	52.0
"	1899	240	300	410	330	240	290	36	....
Apr. (1-14)	1898	...	330	620	...	430	450	67	66
"	1899	670	1020	1020	790	420	680	70	....
May	1899	580	860	1560	580	420	650	70	72.1
June	1898	...	1230	1310	1000	540	810	63	77.5
"	1899	...	1240	1280	520	400	700	86	....
July	1898	...	750	750	525	600	780	84	76.3
"	1899	270	1030	1490	940	340	690	77	....
Aug	1898	594	1000	1025	520	960	900	66	64.3
"	1899	240	1400	780	690	350	480	75	....
Sept	1898	330	1210	1020	530	540	810	62	65.2
Oct. (15-31)	1897	...	460	730	...	180	430	80	63.2
"	1898	...	368	515	300	230	370	35	....
Nov.	1897	59	380	420	145	120	260	27	43.3
"	1898	93	350	480	240	170	285	47	....
Dec.	1897	110	280	350	220	110	220	21	31.3
"	1898	160	240	220	....	102	180	46	....
Mean		180	560	720	485	320			

* Monthly Percentage of Sunshine 8-10
¶ Normal Monthly Percentage of Sunshine 8-10

Monthly Mean Brightness of Sky at 12.30 p. m.

Table 2.

		Class 1	Class 2	Class 3	Class 4	Class 5	Mean without regard to Class	*	¶
Jan..........	1898	...	500	290	380	200	370	63	53.6
"	1899	270	490	250	320	140	280	61	....
Feb..........	1898	120	620	200	510	580	520	59	66.7
"	1899	...	550	210	190	200	390	59	....
Mar..........	1898	...	650	650	1130	350	610	67	65.2
"	1899	350	610	470	240	490	520	51	....
Apr. (1-14) ...	1898	...	920	1260	310	880	710	67	75.2
" ...	1899	670	1200	590	720	620	760	82	....
May..........	1899	1130	840	520	830	710	720	85	81.2
June.........	1898	180	2700	3400	1460	750	2200	70	83.3
"	1899	...	1240	970	980	540	980	86	....
July..........	1898	...	1700	1250	830	770	990	86	79.5
"	1899	330	1250	880	890	590	860	82	....
Aug..........	1898	...	2100	920	1140	1050	1440	82	83.1
"	1899	...	1350	....	480	650	670	87	....
Sept..........	1898	...	1020	1080	870	800	950	76	72.5
Oct. (15-31) ..	1897	170	....	550	500	190	370	87	73.7
" ..	1898	...	650	440	400	340	520	45	....
Nov.	1897	50	530	470	270	140	610	48	56.8
"	1898	60	610	630	170	180	430	57	....
Dec..........	1897	110	280	340	200	180	230	42	48.9
"	1898	280	360	380	280	140	270	63	....
Mean........		310	960	750	590	460			

* Monthly Percentage of Sunshine 12-1
¶ Normal Monthly Percentage of Sunshine 12-1

Monthly Mean Brightness of Sky at 4.30 p. m.

Table 3.

		Class 1	Class 2	Class 3	Class 4	Class 5	Mean without regard to Class	†	‡
Jan..........	1898	...	24	....	35	24	29	30	36.6
"	1899	4	7	30	52	25	25	43	....
Feb..........	1898	...	71	130	125	105	97	28	39.4
"	1899	...	56	....	90	52	66	33	....
Mar..........	1898	...	95	260	90	120	120	57	40.5
"	1899	100	125	190	170	...	210	16	....
Apr. (1-14) ...	1898	...	280	....	....	110	220	41	54.4
" ...	1899	...	400	420	260	180	240	50	....
May..........	1899	78	430	320	360	200	290	49	57.7
June.........	1898	...	900	....	360	260	500	56	67.1
"	1899	460	360	400	300	190	300	70	....
July.........	1898	...	720	...	400	310	350	88	70.4
"	1899	33	320	280	450	210	250	60	....
Aug..........	1898	...	610	460	620	330	520	60	67.2
"	1899	...	....	....	204	160	200	83	....
Sept..........	1898	...	430	480	260	450	370	46	54.2
Oct. (15-31) ..	1897	...	19	....	....	8	16	49	50.4
"	1898	40	48	88	110	77	63	19	....
Nov..........	1897	23	29	48	20	25	32	21	36.8
"	1898	...	10	21	....	15	13	40	....
Dec...........	1898	5	5	....	4	6	5	43	31.5
Mean.........		196	620	560	435	310			

† Monthly Percentage of Sunshine 4-5
‡ Normal Monthly Percentage of Sunshine 4-5

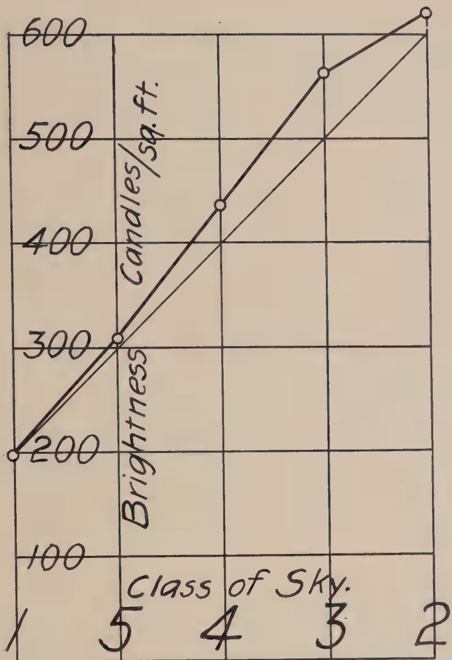


FIG. 1.

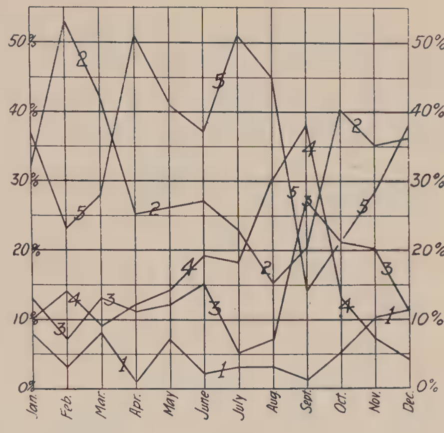


FIG. 2.

constant brightness throughout the year. That this is not true is shown in the tables. The mean observations for Class 2 for December fall below 200 candles, while those for June are above 1,200 candles.

Figure 2 shows how the observations throughout the year were distributed among the different classes of sky, expressed in per cent of the whole number of observations for each month. Thus, for June there were taken about 140 observations. One sees from the table that about 2% of these belonged to Class 1, about 27% to Class 2, 15% to Class 3, 19% to Class 4 and 37% to Class 5. Throughout the year, except perhaps in September, Classes 2 and 5 are seen to be the most important ones, while Class 1 seldom rises above 5%. Classes 3 and 4 seem closely related and assume considerable importance only in the fall.

The tables in the two right hand columns give the percentage of sunshine at the corresponding hours for the several months as recorded at the Chicago office of the U. S. Weather Bureau, also mean sunshine values for ten years. Sunshine is recorded by an automatic device operated by the radiant heat from the sun and so set

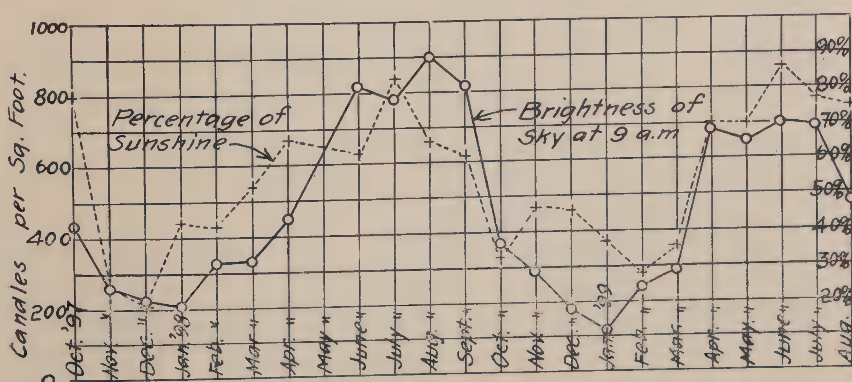


FIG. 3.

as to make a record whenever the sun's disc is clearly visible. It seems that there should be some relation between the mean percentage of sunshine and the mean brightness of the sky. In order to obtain some idea of this relation for the monthly mean values, the curves shown in Figures 3 and 4 have been plotted from the values given in tables 1 and 2. In the first figure the two variables correspond as nearly as one could expect; the relation is direct in the main, (i.e. both increase or decrease together) but sometimes they seem to vary inversely. This correspondence does not show at all clearly in the curves of Figure 4 for midday observations, a point which calls for further study.

If from the tables one finds the mean brightness per month for each hour at which observations were taken and if he then takes the mean of these monthly values the result will be the annual mean, and is for morning 480 candles, for midday 710, and for evening 190. In Figure 5 these numbers are plotted to the scale

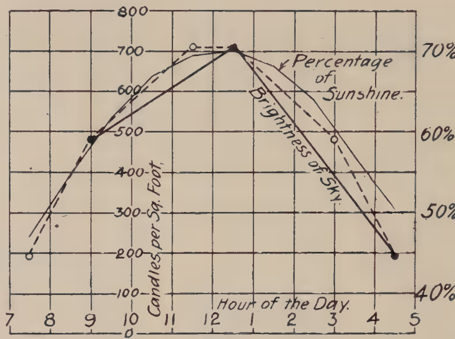


FIG. 5.

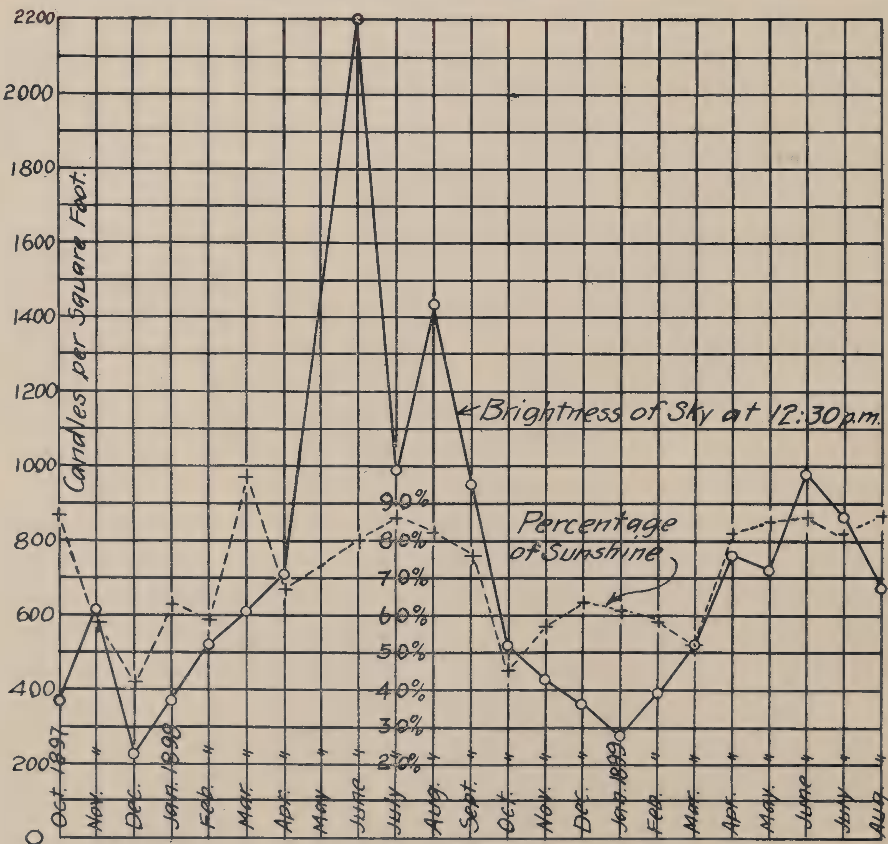


FIG. 4.

of brightness shown and at their appropriate hours. The heavy line connecting these three points may be taken to represent the brightness of the sky throughout the day. We wish now to arrive at some one number which represents the average yearly brightness of the sky during office hours, i.e., from 9 a. m. to 4:30 p. m. If we take one-fourth the sum of the morning value the evening value and twice the midday value we shall have a mean correct within a few per cent. The result is a little over 500 candles per square foot, but since 500 is easily remembered and since two years is too short a time to determine such a constant within several per cent, we shall call 500 the mean annual brightness of the zenith sky at Chicago.

Considering Figure 5 again we might expect the curve representing the brightness of the sky to be symmetrical about the vertical 12 o'clock hour line, i.e., we might expect the mean brightness to be about the same at 9 a. m. and at 3 p. m. and likewise for the other points. Following this suggestion the three points at 7:30, 11:30 and 3 o'clock have been entered in Figure 5 and the six points thus obtained have been connected by a dotted line. The result is seen to be a curve something like the mean daily sunshine curve also shown in this figure to the scale at the right. It is quite natural to suppose that the two curves should be similar for the middle six or seven hours of the day. For the part of the day in which the two curves do coincide to the scales given in Figure 5, we have,

$$b = 20\,(p - 35). \quad \text{Eq. 1.}$$

in which p is the mean percentage of sunshine for any hour and b is the mean brightness of the sky for that hour.

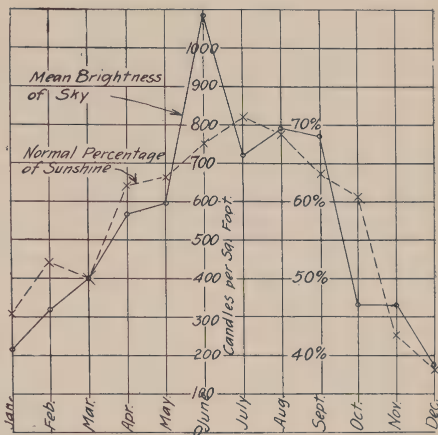


FIG. 6.

In Figure 6 we have the mean daily brightness of the sky for each month plotted to the scale shown. Each point was obtained by taking one-fourth the sum of the morning value, the evening value and double the midday value as explained above. The information given by this curve is similar to that given by Figures 3 and 4, but each point here plotted represents about six times the observations represented by a point in the former figures. The interesting thing about this figure is that it seems to show a tendency of the sky curve to approach the form of the sunshine curve, as the number of observations increase. The most serious divergence between these curves is in the month of June. This, however, is probably due to the apparently exceptional brightness of the June sky in 1897, which was about double that of June, 1898, as shown by the tables. It seems quite likely that further observations would make these curves practically coincide.

(To be Continued.)

Meters and Meter Reading

By Norman Macbeth.

Practically all of the meters in general use today are watt hour meters, also frequently called integrating or recording watt meters. The dials register the use of electrical energy in watt hours, which term is defined electrically as a current of one ampere flowing under the pressure of one volt for one hour. Bills are ordinarily figured in thousand watt hours or kilowatt hours, which is practically the result of eighteen to twenty sixteen candle-power lamps, depending on the efficiency of same, burning for one hour, or nine or ten lamps for two hours, etc. An electric meter is an electric motor, the speed of which depends on the amount of energy flowing through same as required for lamps or motors on a consumer's service, and should not register when current devices are not in use. They do register, however, when over compensated or too finely adjusted to overcome the friction of the bearing; this condition is called "creeping."

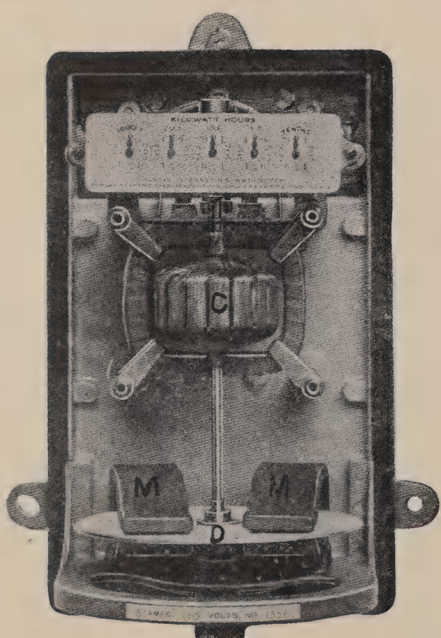


FIG. 1.

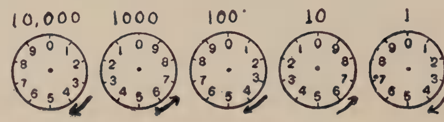


FIG. 2.

The shaft or armature of this motor is in an upright position, the top of same connecting with the gearing on the back of the meter dials (Fig. 1). A very small force would cause the armature C to rotate very rapidly and it is necessary to provide some means for governing the speed and the action of same. To accomplish this, permanent magnets MM are provided between the poles of which a disc D attached to the armature shaft revolves. These magnets have a breaking effect on the disc, retarding its speed. A slight change in their strength, due to improper ageing, an overload of the meter, or a short circuit will cause a change in their strength and a considerable change in the accuracy of the meter. Weakened magnets are responsible for a large number of fast meters, show a considerable increase in the monthly bill, without value received. In other words, a fast meter does not increase the efficiency of a lighting or power installation. The lamps do not give more light nor will the motor have done more work than on a bill for a lesser amount on an accurate meter.

(Fig. 2) Dials all register in tenths or tens, the lowest reading pointer being the one on the extreme right facing the meter. It will be seen that the ratio of velocity of the neighboring pointers is ten to one, the wheels of the shaft to the right gearing into the pinion of the shaft just to the left of it. This accounts for the alternate direction of rotation of the pointers. The value of one division on the first dial on the right is one-tenth, the next dial units, the next tens, the next hundreds and the next thousands. The

value of these divisions, however, is placed by different manufacturers at various points. In some meters they are tenths, some units, or quarters, halves or multiples of ten as the case may be, according to the constant or dial values as marked on the face of the dial. These values must be determined by *a careful consideration of the figures given above or below the dials* and with reference to the illustrations following it is hoped that a fair understanding may be secured.

Each dial, you will note, is divided into ten divisions, one revolution of the pointer of any dial is equal to one division of the dial of next greater value. Dials are read in the order beginning with that having the lowest capacity, writing the result from right to left. In the reading of the

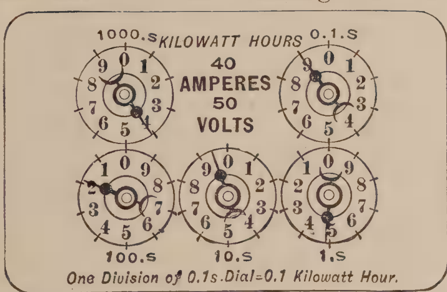


FIG. 3.

dial shown in Fig. 3 the upper right-hand or tenths dial reads 9, the second dial 4, being practically nine-tenths past 4 and will not be 5 until the first dial has reached nought or zero. The third dial reads 9, being four-tenths of a division past 9. The fourth dial reads 1, being nine-tenths of a division past 1, this dial will not read 2 until the previous dial reaches nought, which will not occur until the second dial has gone around practically five-tenths of a revolution, when the first dial will have gone around over five times. The last dial reads 4 and as each division of the first dial is one hundred watt hours or one-tenth kilowatt hour, the result is 4,194,900 watt hours or 4,194.9 kilowatt hours, placing the figures as read from right to left.

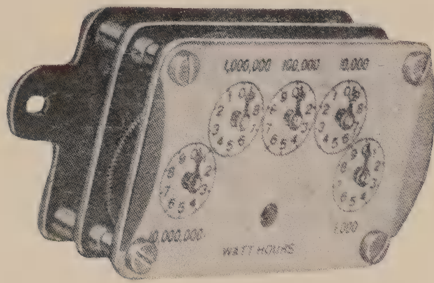


FIG. 4.

Owing to the closeness o1 the observation required and the possibility of error caused by the angle at which the observation is taken, it is necessary to read all dials after the first in connection with the one of next lower value and from a point where the line of observation will be at right angles to the dial face. In Fig. 4 all dials are at zero, although they do not appear to be, owing to the angle.

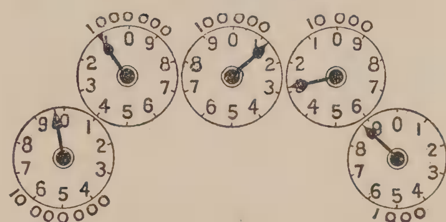
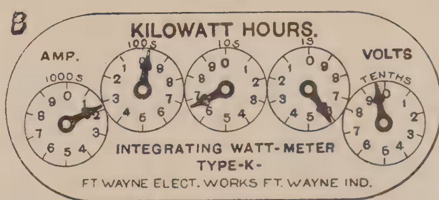


FIG. 5.



READING—1965.9 KILOWATT HOURS.

FIG. 6.

In Fig. 5 one complete revolution of the right-hand dial is 1,000, therefore each division is 100—this dial reads 9,112,800, and should be considered only as the meter registration, the value of this result depending on the multiplying constant of the meter or the value of the units as stated on the dials.

Fig. 6, each division of the right-hand dial marked tenths is one-tenth

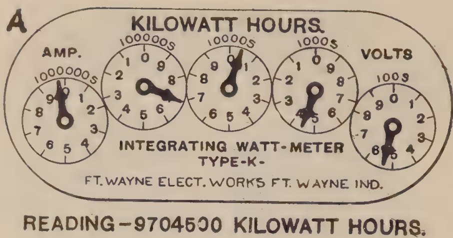


FIG. 7.

of a kilowatt hour, or 100 watt hours, and reads, 1,965.9 kilowatt hours.

Fig. 7, each division of the right-hand dial marked 100s is 100 kilowatt hours and reads, 9,704,500 kilowatt hours.

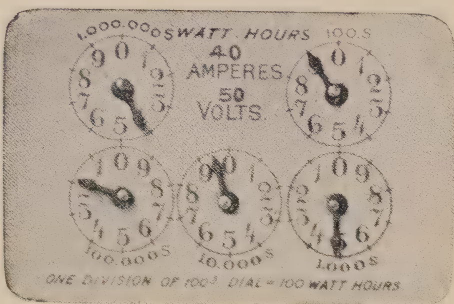


FIG. 8.

Fig. 8 is rated in 100s-watt hours, not kilowatt hours as in Fig. 7, and therefore reads, 4,194,900 watt hours or 4,194.9 kilowatt hours.

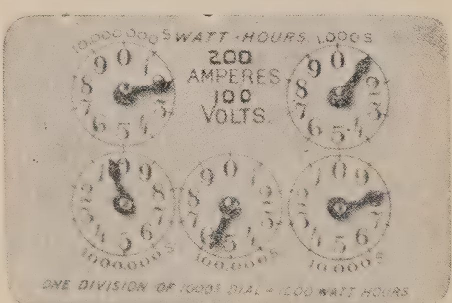


FIG. 9.

Fig. 9 reads in 1000s-watt hours and reads, 20,581,000 watt hours or 20,581. kilowatt hours.

Fig. 10 reads in 1000s also, but in this case as in Fig. 9 each division of the lowest dial is 1000 kilowatt hours or a total of 26,583,000 kilowatt hours.

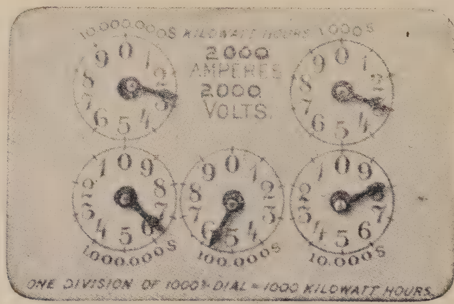


FIG. 10.

Fig. 11 has but four dials, the lowest value being 1s in kilowatt hours, gives 9,659 kilowatt hours.

Fig. 12 reads in dollars and cents direct, the meter being adjusted to conform to the rate in cents per kilo-

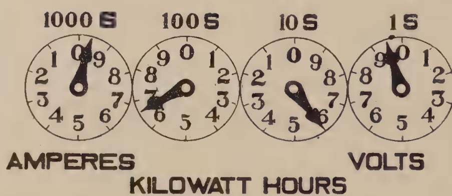


FIG. 11.

watt hour, the first two dials on the right reading in cents and the balance in dollars.

FIG. 12.

Fig. 14 uses but four dials and reverses the direction of rotation of the first dial indicating 0561. kilowatt hours. With this exception, all the

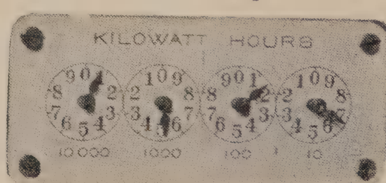
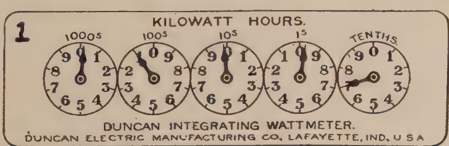


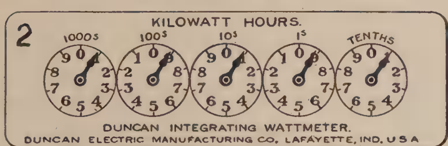
FIG. 13.

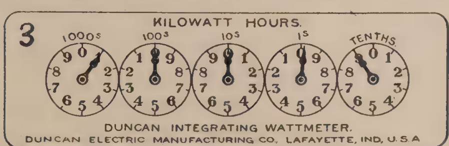
above dials of lowest value revolve in the same direction as the hands on a clock.

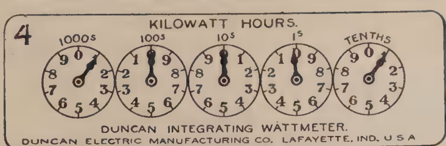
Meter readings are cumulative and always represent total registration from the time the meter was started. To obtain registration for any given period, deduct reading at beginning of period from that at the end, multiply the result by the constant for watt hours, or place a decimal point if the lowest dial reads in tenths, or tens, units or decimal parts of units.

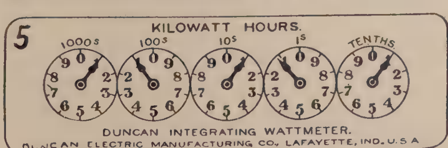
The following set of dials, being taken as more than ordinarily difficult, when understood should qualify any consumer to read his meter. Suppose a meter were installed for a load of 50-16-c.-p. lamps or a 3 h.-p. motor in use six hours per day, meter installed June 20th with all dials at zero. On June 27th, after five days and a half run, the meter reads as in Diagram 1. The first or lowest dial on the extreme right indicates .7 (seven-tenths), the next 1s, indicates 9, the next 10s, indicates 9 and the next, or











100s rests apparently on 1, but since the 10s dial has not yet completed its revolution the 100s dial indicates 0 as does also the 1000s dial, making a total reading of 0099.7 kilowatt hours and a charge from June 20th to June 27th of 99.7 kilowatt hours, or 99,700 watt hours. On August 22nd, 48 days later, the dials appear as in Diagram 2, 0909.1, from which we deduct the reading on June 27th, 0099.7, giving a registration of 809.4 kilowatt hours for June 27th to August 22nd. On August 28th—five days later—Diagram 3 reads 0999.9, deducting 0909.1 of August 22nd gives 90.8 kilowatt hours for August 22nd to August 28th. Half an hour later this reading is verified by Diagram 4, when the dials show 1000.1, an addition of .2 kilowatt hours or 200 watt hours.

On September 5th Diagram 5 reads, 1111.1 from which subtract previous reading 1000.1, showing a use of current to equal 111. kilowatt hours. Always read the figure the pointer has passed, proving same by reference to the next dial to the right. An over reading or an under reading will not be fully corrected on the following charge if bills are subject to a sliding scale of discounts.

In taking regular records of meter readings, read as blank dial cards similar to Fig. 2 should be used as it is easily possible to make mistakes by taking the values direct in figures. A record of this kind may be worked out later by one more conversant with meter readings. Care should be taken, however, to mark each pointer exactly where it appears on the dials. A dial read from the angle of Fig. 5 would appear and might be read as 0919.0, but when worked out carefully beginning at the right-hand dial, would prove all dials at zero.

Watt hour meters on lighting circuits are the acme of the "heads I win, tails you lose" system of getting all that the tariff will stand.

One 16 c.-p. lamp, burning one hour at the normal rated voltage, will

give 16 c.-p. equivalent in light for an approximate charge of 50 watt hours. Suppose for comparison the rated voltage is 110 volts, with a correctly rated 110 volt lamp, the voltage drops to 108 volts or actually 1.8 per cent, the candle-power will drop 9 per cent or to 14.55 c. p., while the watts per hour remain about 48, or a reduction of less than 4 per cent. Again a drop of less than 4 volts to 106.2 will show a reduction in candle-power to 13.2 c. p. or 17½ per cent with a reduction in the watt hour charge of only 6.8 per cent, a charge of 46.6 watt hours.

From the above you will note that all reductions in light due to voltage fluctuation have a considerable influence on the light delivered, but little on the revenue returned percentage in watt hours resulting in equal percentage in dollars. Increases in voltage act quite the same way with always increased revenue as a premium for faulty service.

A consumer decides that he can afford to use incandescent lamps to light a particular part of his store when the lamps are in use possibly six hours per day. The estimates are carefully made as to the probable cost, based always on the rated voltage of the lamps to be installed; 110-volt lamps are regularly used, or perhaps 108-volt lamps labelled 110. During periods off the peak of the load, when fewer consumers are using current, before 4 p. m. or after 7 p. m., the voltage runs up to 120, only an increase of 11 per cent; the watt hours charged by the meter, however, will be 26½ per cent additional. Of course it will be explained you get much more than 16 c.-p. in light, but for a very short time only and this gentle roast repeated a few times will leave your lamps where the original rated candle-power will be a thing of the past, and the lamp salesmen will get about 60 per cent more business than anticipated.

The above conditions prevail mostly on alternating current circuits, excepting on direct current where at this time of the year consumers are more generally making a demand for the capacity of the generators and the much talked of "machinery lying idle throughout the greater part of the year to supply the total demand for fifteen minutes during the extreme peak on a certain day in December" fails to respond, the law of average having been too finely shaved down. Should a consumer protest, very satisfactory explanations are given by the company's representative, who in many cases is not conversant with the conditions nor capable of making a clear statement of fact. A young college graduate, whose father has stock in the company or desirable political connections and ambitions to represent a large corporation, quickly assumes the popular idea of "monopoly corporation importance" and shoulders it all himself—the consumer can either figure out that he is being handsomely treated or he may return to gas. "Our service is above common criticism."

Thousands of consumers during these winter months will pay for "hot wires" 20 per cent. and 30 per cent. below rated candle-power, almost as much as for the light they contract for and which their company agrees to give them, subject to the usual contract protection of "unforeseen demands and acts of Providence" beyond their control.

Watt hour meters make this condition possible as they constantly add to the revenue whichever way the voltage goes.

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REMOVAL

This number of THE ILLUMINATING ENGINEER is issued from its new home, 12 West Fortieth street. This removal was necessitated by the demands for much larger quarters, occasioned by the growth of business connected with our publication. We take this opportunity of expressing our deep appreciation of the patronage and good-will which we have received, and which have been extended to us beyond our most sanguine expectations. With greatly enlarged facilities, it is our purpose to extend the scope and improve the general quality of the matter presented, and to spare no efforts to make THE ILLUMINATING ENGINEER worthy of the very cordial reception which it has received from the public.

Our present location is very central, being within two blocks of the Grand Central Station; within a block of the new Engineering Societies' Building, and directly across the street from the New York Public Library, now nearing completion. A number of the newest and finest hotels are also within a few blocks.

We extend a cordial invitation to all our friends and patrons to make our offices their business headquarters while in this city. Telephone and stenographic services will be gladly placed at their disposal, as well as the usual office conveniences for correspondence. Come in, and make yourself at home.

RAISING THE STANDARD OF ILLUMINATION

The meaning of the above expression is susceptible of two different constructions. It may imply an increase in the general intensity of illumination produced, or it may refer to a higher standard of quality in the results obtained. When taken in this latter sense it furnishes in a single statement the general purpose and aim of illuminating engineering. But as we have pointed out before, a higher standard of quality in illumination does not of necessity signify the raising of the intensity of illumination with the consequent increase in the quantity of light used. The *Electrical World* argues for a general increase in illuminating intensity, and maintains that the new high efficiency incandescent lamps, which must sooner or later supplant the carbon filament lamp now in general use, should be manufactured in wattages corresponding to the wattage of the various candle-powers now in use. Thus, the lamp corresponding to the present 16 candle-power size, taking 3 1-2 watts, would, in the case of the most efficient form of the new lamps, have 56 candle-power. The 30 watt lamp, corresponding to the present 8 candle-power, would be of 30 candle-power, while the lamp corresponding to the 32 candle-power would be of about 110 candle-power. While doubtless many lamps of these high candle-powers would be used in place of clusters of 16 candle-power lamps now installed, it is perfectly plain that lamps of the present familiar size, that is, of 16 and 8 candle-power, must continue to be largely produced to fill public demands. There are a vast number of cases in which single lamps

of these candle-powers have been installed and furnished ample light for the purposes intended.

We have previously called attention to the incongruity of rating a lamp by its wattage. Expressed in plain terms, this method is simply a device for hoodwinking the public. To the general user "watts," or "wattage" means absolutely nothing, whereas "candle-power," especially "16 candle-power," is a term well understood from long continued use. If any change is to be made in the terms used for commercial rating of a lamp it should be the substitution of actual, that is, mean spherical candle-power, for mean horizontal, which is now the common practise. We believe that it is always best to be honest with the public, and that, at the present time in particular, the general public is in no mood to condone any attempts at sharp practise, especially on the part of corporations supplying the means of producing artificial light.

The commercial problem involved in the substitution of a 1 watt lamp for the present 3 1-2 watt lamp is one which rightly gives occasion for much serious thought on the part of the business managers; but in general there is no more reason to believe that the ultimate total business of central stations will be reduced thereby than for the groundless fear that commonly arises on the introduction of any new and revolutionary mechanical invention.

Cheapening electric light will inevitably increase the total amount of light used, and will furthermore largely tend to divert the use of electric current into other channels that are now camparatively unimportant; and this diversified use, it is needless to say, offers a larger measure of profit to the central station than the same total amount used for a single purpose such as lighting.

Our contemporary "is not at all in sympathy with the idea that the amount of artificial illumination common today is too great," and thinks "we have a long distance to go yet in most artificial lighting installations before we arrive at a foot-candle illumination equal to that produced by daylight in rooms well provided with windows. Until we get up to that point there is no cause for worry as to excessive illumination." The idea that artificial lighting rarely, if ever, comes up to daylight illumination under favorable conditions, is not well founded. Dr. Louis Bell found the intensities of daylight illumination, "on a bright but not sunny day, at a time early in the afternoon," to be as follows:

Facing a south window......	6 ft. candles
Facing an east window.......	2.2 ft. candles
Facing a north wall..........	7 ft. candles
10 feet from south window on a misty April day, 5 p. m..	5 ft. candles

He further states that "on a clear day the diffused illumination near a window, while the sun is still high, will generally range from 5 to 10 ft.-candles, while in cases where there are exceptionally favorable conditions for brilliant illumination it may rise to twice, or even four times the amount just stated."

By reference to the articles giving the intensity of artificial illumination from actual measurement, which have appeared in previous issues, it will be seen that both the maximum and minimum average values of illumination exceed those given by Dr. Bell for daylight, except in a very unusual condition. It thus appears that in cases that are at present considered well illuminated the intensity of illumination exceeds that of the average daylight illumination.

The enormous difference in quality between electric light, or any other of the present forms of artificial light, and diffused daylight, should not be lost sight of. The most important single quality of light, so far as its hygienic effect is concerned, is diffusion; and in this respect there is simply no comparison between the best efforts at artificial illumination, even by the so-called "indirect" method, and the dif-

fusion of daylight. The more intense the illumination the stronger the glare. To sit within three or four feet of a cluster of lamps, under an efficient reflector, with an illumination on the page of 12 or 15 foot-candles—conditions actually existing in a case recently observed—is an outrage upon the eyes, as well as upon common sense, which requires "no fine spun theories of illuminating engineering" to demonstrate. We still maintain that excessive illumination, with the almost invariable, if not necessary accompanying glare, is quite as much in evidence at the present time as insufficient intensity. Such cases, however, are very largely confined to spaces or rooms to which the general public have access. In private offices, work rooms, and other places which the public do not see, but where the exactions of labor require the most careful consideration of the eyes of the operator, insufficient illumination is only too frequently to be met with. In this class of cases the cry for an increase in the standard of illumination is quite justified. In general it may be said that both maximum and minimum degrees of intensity are often exceeded, and it is one of the provinces of the illuminating engineer to correct both of these abuses.

COST OF PROPER MAINTENANCE AS AN ITEM IN DETERMINING THE GENERAL EFFICIENCY OF ILLUMINATING SYSTEMS

The excessive waste of light by reason of poorly designed fixtures, crude devices for producing diffusion, and injudicious distribution of the lighting units, has naturally been the first, as it is the most serious, abuse to receive attention from illuminating engineers. Naturally much has been said and done in the matter of proper distribution of light, the determination of the various intensities requisite for different purposes, the most economical means of securing diffusion, and the necessity of co-ordinating the artistic and practical elements of the problem; but the various matters relating to the maintenance of illuminating systems has received much less attention. In figuring the efficiency of a given illuminating installation the quantity of electric current or gas consumed may be very readily determined; and the total quantity of light produced, as well as the intensity of illumination on any assumed surface, may also be predetermined within comparatively small limits of error. Theoretical efficiency is, therefore, very easily determined. There are two other factors in the case, however, which, if not of equal importance, at least demand careful attention in the general solution of any illuminating problem. These are: first, what may be called the cost of mechanical maintenance, that is, the expense of keeping the apparatus in good running order; and second, the reduction in illumination due to deterioration of apparatus by use. An important item in connection with both of these factors is the question of dust. It is one of the anomalies of illumination, that a merchant will have his windows carefully cleaned every morning, and leave the globes and shades used with his artificial light untouched for a year at a time. This comparison is no mere literary exaggeration, but an actual fact that has come within our own observation. We have known of cases where thoroughly good globes have been taken down and thrown away, and replaced with much less efficient glassware, for the simple reason that they had become so thickly coated with smoke and dust as to become semi-opaque: the simple operation of washing with soap and water would have restored the globes to their original efficiency and beauty. There is even a popular notion that glass does not hold its original brilliancy of surface in use—a notion, however, which is applied only to glassware used for lighting purposes; tableware being, by reason of its use, kept reasonably clean, is not included. As a matter of fact, the surface of glass is probably the most permanent in its nature of any substance made by man,

and the easiest cleaned. When the value of prism glass for increasing daylight illumination was being commercially demonstrated by the Luxfer Prism Co., in Chicago, they found it profitable, if not absolutely necessary, to employ at their own expense cleaners to see that the installations which they put in were kept reasonably free from the natural accumulation of grime, as they could not depend upon the glass, after being installed, receiving the attention that had been previously given to the plain glass windows which it replaced.

The mechanical construction of fixtures and apparatus so as to render the removal of the glassware for cleaning purposes as simple and easy as possible, is a matter which should have the careful consideration of illuminating engineers. This is a matter that is generally entirely overlooked by the fixture manufacturer. In many cases fixtures are sent out and installed which are so complicated in their construction as to require an engineer to get at the glassware for cleaning or to replace electric lamps that have burned out.

The accumulation of dust on an incandescent lamp bulb may readily reduce the light 20% to 30%, and yet it is by no means an uncommon practice to allow lamps to burn their entire life without being once cleaned. The illuminating engineer should therefore make it a point to see that apparatus is so constructed as to enable it to be cleaned, and the necessary renewals of parts made, with the least possible trouble and expense; and furthermore, that the construction is such that the accumulation of dust will have a minimum effect upon the resulting illumination. He should then impress upon his clients the actual saving in dollars and cents, as well as the great improvement in appearance, that can be secured by having all apparatus kept clean and in good working order. In many installations of even moderate size it would be profitable to employ a special attendant for this purpose; and in all cases it should be the special duty of some employee to see that the lighting apparatus is in good condition.

In case electric lamps are used the question of renewals is one of importance, and to which considerable attention has been given; but, generally speaking, only with regard to the deterioration incident to the nature of the lamp. Aside from this natural deterioration, however, there are a number of conditions which may strongly affect its economical life. It has been clearly shown that anything which confines the heat of a lamp shortens its life. Frosting or etching the lamp reduces its life 40%, as shown by careful tests. The bunching of a number of lamps close together within a globe or bowl of semi-transparent glass will also produce similar results.

Another general rule to be observed in connection with an incandescent electric lamp is to avoid wherever possible unusual forms of bulb, or any methods of construction, which add to its cost. A lamp is of necessity a perishable article, and the simplest principles of economy therefore dictate that nothing should be added to it by way of expense than can be accomplished by any other means. All methods of special shaping and silvering of the bulb so as to utilize it as a reflector are therefore illogical, as they add greatly to the original cost of the lamp, and must be thrown away when the filament has outlived its usefulness. The construction of long tubular lamps having a filament running from end to end is indefensible for the same reason, with some possible exceptions, which would be rare, where it is important to place light sources in a concealed position to occupy the least possible space. For all ordinary purposes of illumination the regular commercial lamp is easier to handle, and practically any desired distribution and diffusion can be obtained by use of simple accessories that may be obtained "from stock." It is not a difficult matter to get up many clever and original devices for securing given results; but

the fact that they are in themselves "clever," or ingenious, while it may give them value as museum specimens, does not compensate in a practical way for the added expense in original cost and in maintenance.

In the field of gas lighting slovenly methods in maintaining the apparatus are equally injurious. A punctured mantle often means a broken chimney, and in any case a serious reduction in the light produced for the gas burned. The fact also that a mantle falls off in efficiency by use is even more frequently overlooked, from the fact that there is no warning given by a blackened bulb, as in the case of the electric lamp. The difference in the life of various makes of mantles is also a matter upon which there is practically no general definite information. Relative life of chimneys of different forms and quality of glass is another important item of maintenance upon which accurate data is equally wanting. The use of glass chimneys that have become only semi-transparent by action of the hot gases upon the glass, and of mica chimneys that have similarly deteriorated, are examples of the reduction in general efficiency that occur from neglect of proper care. The expense involved in keeping chimneys clean, and renewing the mantles sufficiently often to keep them up to a reasonably close approximation to their highest efficiency, are items which must be counted into the general expense of the illuminating system.

The whole subject of the relative life-endurance and efficiency of incandescent gas mantles under the varying conditions in which they must be used is one upon which there is comparatively little authentic information, and yet the item of mantle renewals in incandescent gas lighting is certainly comparable with the renewal of lamps with the incandescent electric light. The need of some systematic method of determining these qualities in a mantle, and of commercially stating the results, has been pointed out in the foreign technical press, and some attempts been made to supply the need; in this country Mr. Lansingh has discussed the matter somewhat in a recent paper before the gas institute. In comparing the efficiency of incandescent gas light with flame light, or with electricity, this question of mantle renewals is very often lost sight of. In a case of large installations it would be well worth while for the individual user to have life and efficiency tests made of the various brands of mantles before purchasing.

The relative life of chimneys of various makes and shapes is a matter about which still less is known, and is worth careful consideration, as there is probably no other accessory used in the production of light that is a more uncertain quality.

On the whole, the lack of judgment and knowledge which are so frequently displayed, and have been so often commented upon, in the selection of illuminating apparatus, are fully equaled by the general carelessness displayed in maintaining the installation in use.

STANDARD SYMBOLS FOR WIRING PLANS

We give on another page a reproduction of the chart containing the symbols recently adopted by the National Electric Contractors' Association for use in wiring plans and specifications. It would seem that such a set of symbols should be of the greatest possible advantage to electrical contractors; and as illuminating engineers must of necessity be able to read such specifications intelligently, we have reproduced the chart so as to afford an opportunity of becoming familiar with it.

Correspondence

FROM OUR LONDON CORRESPONDENT

The question of high grade or low grade gas has for some time past occupied the serious attention of gas makers on this side. Sir George Livesey has been a persistent upholder of gas of low candle-power, and the universal use of incandescent gas burners. But there are not wanting those who pin their faith to high grade gas and one of the most continuous and ardent supporters has been Mr. Edward Allen, M. Inst. C. E., engineer of the Liverpool Gas Works; from that works gas of 20 candle-power has been and is supplied. The statutory obligations of the Gas Co. provides that the standard of illuminating power be such as to produce from a bat's-wing or fish-tail burner, consuming 5 cubic feet of gas per hour, a light equal in intensity to the light produced by not less than 20 sperm candles, of six to the pound, each burning 120 grains per hour. These conditions are readily maintained, and under no circumstances is the illuminating power to fall below the standard. Perhaps in no city in Great Britain is the gas supplied more closely tested than in Liverpool.

To maintain so high an illuminating standard the cost of the material required is considerable and makes the price comparatively high. At present the cost of Cannel coal is low and oil for carburetted water gas is at a fair average price, so that the enriching of the gas up to a standard of 20 candles is not now so costly as it would be did high prices rule. It has been stated that the cost of each candle above 16 candles was about 1d. (2c.), but at Liverpool the extra cost per candle would not probably exceed half a penny, or one cent.

Mr. Allen has just contributed an admirable paper to the proceedings of the Manchester District Institution of Gas Engineers upon the method which he adopts with his 20 candle gas and gives interesting particulars, which we will refer to.

As to the question of gas for flat flame burners he says: "For many years 20 candle gas has been supplied, and it was deemed unwise to furnish a lower quality than 16 candles for a flat flame burner. Experiments were made with both qualities of gas as a source of light. It is evident that 20 candle gas at 2s. 6d. ($0.60) is cheaper than 16 candle gas at 2s. 4d. ($0.54) per 1000 feet thus:—

COST OF LIGHT IN A FLAT FLAME BURNER.

Illuminating Power.	Price per 1000 C. ft.	Cost per Candle per 1000 C. ft.
20 candles	2s 6d ($0.60)	1.50d (3 cts.)
16 candles	2s 4d ($0.54)	1.75d (3.50 cts.)

The 20 candle gas contained a mixture of carburetted water gas, varying from 34 to 40 per cent., and the 16 candle gas 50 per cent. of water gas. The tests were made with a Sugg's flat-flame burner No. 7, with steatite bat-wing, and a consumption rate of 5 cubit feet per hour. The incandescent burner was a Welsbach "C," rated to 3 cubit feet per hour. The air supply was regulated to give the best results in each case; as a matter of fact the air required by 16 candle gas was, Mr. Allen tells us, almost the same as for the 20 candle mixture.

The average results of the experiments are shown in the following table:

Burner	20 Candle gas	16 Candle gas	Difference Act'l	%
No. 7 Bat wing	20.61	16.47	4.14	20.09
Welsbach "C"	74.70	63.54	11.16	14.94

COST OF LIGHT TO THE CONSUMER.

Welsbach "C" Burner	Illuminating Power	Price per 1000 C. ft.	Cost per candle per 1000 C. ft.
20 Candles	74.70	30 pence	0.416 pence
16 Candles	63.54	28 pence	0.440 pence

These tables show that a reduction in illuminating power would be detrimental to the interests of the consumer whether the gas was used in a flat-flame or incandescent burner.

Mr. Allen concluded his paper by giving the results of many tests with varying qualities of gas, the results of which are graphically described in the two diagrams.

Mr. Allen calls attention to the beautiful flat-flame illumination given by Liverpool gas, and says: "It is not only the photometric value of the light, but the color and tone of the flame—like a disc of burnished gold—that commands admiration." He tells us that "notwithstanding the fact that for the same consumption of gas six times more light may be secured by an incandescent burner, there are not wanting those in the city who still refuse to substitute the old for the new light. They prefer the rays of light which resemble the golden sunshine to those which emulate the cold, silver sheen of the distant moon."

There are, in this, the "old country," new societies being started every day, one of which that has a good outlook is known as the Association of Engineers-in-Charge; the members are practical or working engineers, who control the engineering departments of large works, look after the power plant, pumps, lifts, lighting stations, and machinery of various domestic or other plants. At the most recent meeting Mr. James Swinburne, F. R. S., M. Inst., C. S., delivered a lecture on "Indoor Illumination," from which many of us thought to learn much; but if we did not come empty away we at least had not to complain of being surfeited with "new bread," the very little that fell on the waters was certainly stale if not unprofitable.

The Professor, in complimenting members of the Association on their temerity in banding themselves together, said: "It is quite worth the while of the man who has to look after the lighting of a big building to become a specialist to some extent in illumination. Some day we may have Illuminating Engineers, who are not Supply Electricians, or Gas Engineers, but concern themselves with the applications of electrical power, gas, petroleum, and acetylene to lighting, dealing with each on its merit without partiality." Quite so, my dear Professor; but a careful perusal of the paper will show that even so gifted a savant at times finds it difficult to avoid partiality.

But to return to the lecture, we quite endorse the statement that, at present, the question of illumination is left generally to architects, house decorators, and chance; chance having by far the most to say in the matter.

The color of artificial light is a vexed point, as we have already in an earlier note shown. The generally accepted opinion is that yellow best suits the eye, but Mr. Swinburne considers that yellow is not a good color and that artificial light should be "as near sunlight, as it reaches the earth, as possible."

Upon general lighting we note the opinion expressed that the really important point is to arrange the lamps so that they will not tire the retina. It is not good, the lecturer said, having 10,000 candle-power in a large room, if you can really see better with 1000 properly arranged. The question of the color of walls and hangings is a matter of importance. The following short statement, if it be not new, is certainly true: "Suppose a large room has a number of small lamps distributed in it it, and suppose the walls are quite black; anything in the room is lighted by the lamps directly, and gets no light from the walls. Now suppose the walls are repapered so as to have a surface which only absorbs half the light that falls on them; this will help the lamps to such an extent that they will give twice the illumination."

Mr. Swinburne would not commit himself on the question of comparative results of varying illuminants, and trotted out Claypole's table, which

gives graphic information; but again it may be true, but it distinctly is not new.

Mr. Swinburne held the balance fairly well between gas and electricity. For the former he had a word to say about the sulphur dioxide bogey, and the destruction of book bindings caused by the use of gas in libraries. He condemned the filament electric glow lamps, saying that it appears to be doomed, as the metal wire lamps seem bound to push it out of existence as soon as they can be made in large enough quantities, and what is more important, as soon as the public get into the habit of asking for them.

Not a word was told the Engineers-in-Charge about self-intensified gas, high-power burners, inverted and angle incandescent burners—the value of the many mantles on the market, the necessity for careful regulation of gas supply and the enormous economy to be gained thereby. No mention was made of the sizes of pipes for a given number of lights or the rate of flow of gas through pipes at a given pressure, all points upon which instruction is much needed.

One of the great needs of the gas consumer has been, for years past, to have some means of switching on the gas and lighting the same without the use of matchers or tapers. To a certain extent this has been accomplished by means of the bye-pass and pilot light attached to each separate burner and operated on each fitting; but such a method does not approximate to the convenience and economy of the switch as used for electric lighting. Efforts have been made with pneumatic gas lighters, but with such systems a second communication has to be established, and so the installing of the pneumatic lighter is expensive and liable to be easily thrown out of gear. There is a prospect of their being largely superseded by a fitting known as the Norwich Tumbler Switch, the joint invention of Mr. Thos. Glaver, engineer of the City of Norwich Gas

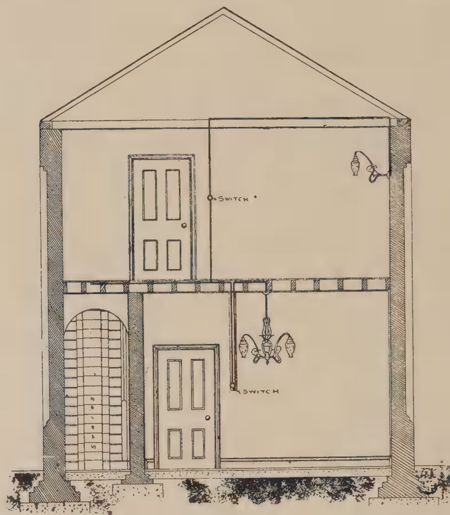
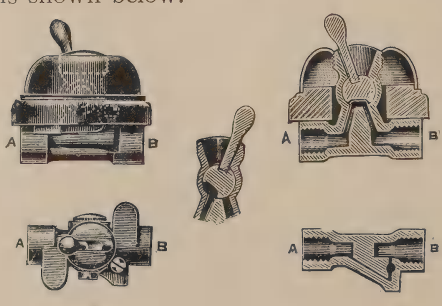


FIG. I.

Undertaking, and Mr. George Hands, of 71 Farrington Road, London, E. C., whose firms are handling the switch commercially.

The illustration, Fig. 1, shows a section of the two rooms and the method adopted in fitting up the switch. It is fixed on to the ordinary supply pipe of the fitting or fittings it is to control; it is constructed with a two-way passage, the arc supplying sufficient gas for a pilot light regulated by an automatic valve, attached to the burner or burners. The pilot is kept alight, but the raising of the tumbler opens the second, or large gas way, and the burner or burners are instantly lighted whether the distance be five yards or a thousand; and so long as they are from one "drop," or supply pipe, any number of pendants or brackets may be switched on or off at the same time. The general construction of the switch is shown below.



In order to provide for varying pressures which would affect the supply to the pilot light the bye-pass passage in the switch has an adjusting screw so that a slight turn will increase or decrease the supply as desired. The switch is covered with a brass or copper mount, the tumbler being similar in shape and action to those generally used for electric lighting. It is convenient that they be fitted just inside the door; the supply pipes may be chased into the walls or cased, according to individual requirements.

The use of the Norwich Switch will be greatly appreciated and induce to much economy where gas lighting is intermittent, as in offices, work-shops, shops, and showrooms. In hotels they will be of special value, as labor is saved, and the consumption of gas greatly reduced, because when rooms are out of use an infinitesimal quantity of gas is consumed.

In connection with the incandescent mantle, and particularly in the inverted form, these tumbler switches will, we are sure, become in a very short time universal, there being no risk of broken mantles through careless lighting. The patent rights for America have been secured, and we hear that a syndicate has been formed to exploit the switch in the United States.

It will, we are sure, interest Illuminating Engineers, and others in America, to know that as an outcome of the Gas Exhibition held in London in 1905, a society of principals of firms interested in the commercial side of gas engineering, manufacture, and distribution, has been formed under the title of the British Society of Gas Industries. The society includes the manufacturers of all gas lighting appliances, and promises to be a large and influential body. The first president is Mr. Dugald Clerk, M. Inst. C. E., F. C. S., who is world-known as an inventor of gas engines, a voluminous writer, and a man of high scientific attainments. In the course of a very few remarks at the inaugural meeting, held last month, he said:—"They were met together not so much as scientific men and engineers as business men with business objects. Their business objects were of the most legitimate kind; they all felt the necessity of co-operation in business, in order to organize to some extent certain parts of their industry. He believed in free trade, and a recent visit to America had given him a wholesome fear of trusts. The society was no ring or trust. Their objects were partly technical, partly scientific, and, he might add, mainly business." A paper was read on "The uses to which gas has been, and can be put, with advantage to the public and manufacturers," by Walter W. Thomas, a gentleman having a large practise as an architect in Liverpool. To a certain extent the paper was historical, dealing with the advances made in the last quarter of a century and coming down to the present time. Mr. Thomas said much about cheap gas, the folly of the municipal authorities, who extensively own gas works on this side, maintaining a high price for gas in order to show large profits and to allocate them for the reduction of rates; we should rather say to the paying for extravagant and unnecessary so-called "improvements" and the bolstering up of municipal industries, that are being carried on at a heavy loss. Mr. Thomas pointed out that the heyday of prosperity for gas undertakings would be reached when all solid coal fires were abolished, and when the atmosphere of such a city as Manchester would be salubrious, free from fog, because free from soot, even in the middle of November. Perhaps his views are Utopian, still the growing use of the gas fire must materially reduce the smoke nuisance and so possibly lessen the sulphurous fog which, in the winter time, hangs like a pall over so many of our large cities.

The president in some subsequent remarks upon the subject of gas illumination said:—"The amount of light obtained by some of the later forms of incandescent gas lamps, with slight re-

generation, rose as high as 30 candles per cubic foot of gas burned; with the ordinary Welsbach burner 20 candles per cubit foot was about the average duty. So that not only was the gas consumed reduced by say, 30 per cent., but the amount of light was increased enormously. The public has been educated to require more and more light, a very important point, apart from cost, and one too often overlooked in this: For a given cubical capacity room they had a certain amount of oxygen, this oxygen was burned up far too freely when the flat-flame burner was in use, the room or rooms were quickly heated and the atmosphere vitiated by the products of combustion; but in using the incandescent light such a small quantity of gas was burned, that the carbonic acid in a room did not rise appreciably; so looking at the matter from that point of view, rooms did not need the amount of ventilation that was imperative when the older system of illumination obtained, Mr. T. G. Marsh, the pioneer of the automatic prepayment meter, remarked that the amount of gas that should be sold for heating should be certainly three times as much as was sold for lighting; he concluded his remarks by saying, that what was wanted were progressive administrators in the gas industry to work with progressive engineers; and then the gas industry would be more successful than it ever has been. Mr. Marsh has gained much popularity by two of his most recent inventions, the rotary meter, and the discount meter; these are being operated and we believe extensively adopted in America, a company having been formed for the purpose of handling both meters.

It may interest readers of THE ILLUMINATING ENGINEER, who are electric lighting engineers, to know that the consulting electrical engineer to the Borough of Marylebone (and of the municipal divisions of greater London) Mr. A. Wright, received as commission on the capitol expenditure the sum of £19,595, 9s. 7d. ($94.958.-30), in accordance with his agreement with the Borough Council.

There is every reason to believe that with us the inverted burners will be extensively used for lighting churches and public buildings. It will be remembered that some time back we noticed the "Bland" light; this burner has been adopted in several churches. We have before us, at the moment of writing, an excellent photograph of the interior of the Parish Church at Ross, in Herefordshire, taken by the light of the Bland burners which have been installed in that church. One full sized inverted burner, if properly regulated, will give the light of at least five flat-flame burners with the saving of quite 25 cubic feet of gas per hour.

It is to be remembered that we gave some details, in an early number, of the illumination of certain streets in the city of London by means of high pressure incandescent gas lamps. A report has been presented by the Streets Committee to the Court of Common Council. From this report we note that the saving in the annual bill for lighting the area, due to the substitution of gas for electricity, has been £490. 10s. 2d. ($2,354.40) or £119 7s. 10d. ($573.10) more than was estimated; the saving on the estimated cost of installation has been £194. 1s. 4d. ($931.52). Considerable extensions will shortly be made and the high pressure incandescent gas lamps will be very generally adopted in the city of London.

CHAS. W. HASTINGS.

[Editor *Gas Engineers' Magazine.*]

FROM OUR READERS

EDITOR, THE ILLUMINATING ENGINEER.

SIR:—The preceding part of my letter has not, with a word, touched on the now by all knowing—and not adversely-interested-ones—a d m i t t e d meritorious qualities of the Cazin-Lamps No. 1, and No. 2 [with metallized (in fact) metal-filaments, without or with oxidized filament-surfaces] nor on the accessories of the lamps.

The three illustrations of the Cazin Lamps (No. 1 and No. 2) viz: without or with oxidized filament-surface, as shown on page 747 of the November issue of THE ILLUMINATING ENGINEER, will cause experts to inquire:

1. What guarantee is there, that the hermetical glass seal will not make the makers of Cazin Lamps *dependents* as well as the makers of the obsolete carbon-filament lamps?

2. Has special provision been made for successfully and hermetically joining the extra large circles of base and bulb edges?

In the matter of Inquiry 1 the facts here below stated will show, that my licensees will be dependent on nobody in the matter of hermetical glass-sealing.

Patent No. 621,292 issued to me on March 14, 1899, on an application made on October 15, 1897 contains on page 2 lines 49 to 53 the following:

"In sealing the wires I preferably make use of powdered glass as a soldering material, causing the closed tube-end and the glass powder to fuse around the wires."

The original of this application contained the following formulated claim, namely:

6. "The process of manufacturing an all-glass polecontact-providing base-part of an electric incandescent vacuum lamp, which consists in fusing the inleading wires first into one end of a glass-tube by means of glass-powder being fused around the inleading wires and to one end of the tube, and in second fusing the preserved cylindrical part in proximity to the sealed part into a circular opening of the main base-part, as and for the purpose set forth."

When the examiner had ascertained, that no anticipating reference against my hermetical sealing of inleading wires by means of fusing glass-powder could be cited, he demanded under April 12, 1898 that this claim, of which he stated, that it was "drawn to cover a process of fusing leading-in wires" be divided from the main claims of the case, which "cover a process of preparing filaments and the article produced by the process, and the construction of incandescent electric lamps."

To avoid useless further argument on a claim, which under the rules had to be and had been demanded to be divided out, the claim was begun, divided out and inserted into another application, which is yet pending at this date. This gives all lamp-makers the liberty of using this method of hermetical sealing without squeezing the tube, thus making dependents independent, and independents unmolested by third parties.

All drawings to the many lamp patents issued to me thereafter bear evidence of the use of pulverized glass in hermetical wire-sealing.

There is no absolute necessity of using wider bulk necks with the Cazin-metallized metal filaments, if these filaments take the form, as it is shown in the frontispiece to the Cazin book, the Twentieth Century Electric light. But not withstanding this simple U-form is not the one closest adapted to optical requirements. The bulbs may then have so narrow necks that the glass work may be done in the present trade method.

The wider necks are desirable because with them there will be no squeezing of loops in the Cazin-filament, when the filaments are inserted into the bulb. The very fact, that the Cazin metallized metal-filament are stiff enough to carry their own weight with even much less vibration than the carbon-filament does, is the cause, that, when squeezed through a narrow neck, they may be kinked in the apex of the loop. And though such kink may remain invisible, it produced a differentially weaker point in the filament, which will succumb first and shorten the life of the lamp.

The glass-soldering applying to extra large necks mainly is the subject matter of four applications (covering method and apparatus), on three of which patents have been issued, namely No. 770,221, 762,263 and 770,222 and the fourth of which has been allowed and will be issued in less than six months, covering fully method, apparatus and product.

The same apparatus serves for taking the glass-soldered parts of the lamp apart, when the filament is to be renewed. This is provided for by the temperature of fusion of the glass solder being made much lower than that of the glass parts themselves, which has the effect that, when the joints are uniformly heated by the apparatus, the parts can easily be drawn apart. The solder glass is colored to indicate its presence in the joints.

It should be well understood, that my present statement relates exclusively to the Cazin Lamps No. 1 and No. 2 such as illustrated on page 747 of the November issue of THE ILLUMINATING ENGINEER, and does not relate to the Cazin Lamp No. 3 such as illustrated on page 746 of the same. This No. 3 is not as well adapted for domestic lighting or low candle-power as No. 1 and 2. Metallized metal filaments, without or with oxidized surfaces, are destined to take its place in public localities and streets.

The following fact about the Cazin Lamp No. 1, now ready to enter the public market, may therefore be positively stated, namely:

1. The Metallized Metallic Filament of the Cazin Lamp supports and carries its own weight and does not require, as all the purely metallic filaments (Usmium, Tantalum or Tungsten) do, a special non-conducting supporting element as part of the luminant structure. (It may here be also stated, that by an application of October 2, 1899 Cazin secured protection for such a support for the eventuality, that he might elect to make use of purely metallic filaments of the class of metals, as protected by his patent privileges.)

And the Cazin metallized metal filament is fit for regular use in all present bulb lamp equipments and under prevailing conditions of publicity available electric currents, and fits with the bases of the lamps containing them into existing sockets of all kinds, and does not require, as the Osmium and Tungsten lamps do, the mounting of a special adapter, of material cost and inconveniece, to use a plurality of lamps on one socket.

2. The light produced by the Cazin lamps is brilliant white, but without offending the human eye by sparkling or emitting visible single rays.

3. The wattage of the Cazin Lamp No. 1 is warranted to be during its entire life of not less than 500 hours, below 2 watts per candle power, but is in fact on an average 1.75 watts per candle power, and will remain so for over 500 hours, unless damaged by touch of hand—all unnecessary handling by taking hold of the filament itself should therefore be avoided and becomes avoidable by their being mounted on a visible glass interior and being platted.

4. The average life of the Cazin filament is 500 hours, but they are known to remain in normal service up to several thousand hours, the length of life essentially depending on this, that during bulb evacuation the current tension is regulated according to my instruction, and producing the carbonization of the metal in the filament, by mutual inter-impregnation (protected by patent) of metal and carbon, the surface, being meanwhile protected against excessive oxygenation by the presence on the surface of rare metals.

Were it not that hundreds of years of experience in all civilized countries on the face of the earth have established the fact, that the use of all common utilities, to which light producers undisputedly belong, increases and expands at a proportionate rate and in excess thereof, as such utility is of-

fered in more adequate condition and at lower proportionate prices, central stations might oppose the introduction of the Cazin lamp, as so many fundamentally progressive improvements have been opposed by selfish, blind and mistaken interests.

As it is, they may, without increasing their plant, furnish double the light, with the current now by them produced and sold. And all experience indicates, they soon will find their business expand to all, that they can supply and to more than that.

The public demand for illumination has increased during my lifetime from the street oil lantern to the electric light—a few years more will see it advanced from the color-spoiling carbon-filament to the color-preserving, metallized (in fact) filament.

To you, Mr. Editor, who is well posted as to the facts of the case, it must have caused the sensation, that is called fun, to place in your issue for November, as a kind of preface to my letter, the statement of Dr. Louis Bell, when speaking of the "remarkable progress in methods of producing light, particularly from the electric current" in the (London) *Electrician*, to the effect that "practically all of the research work which has resulted in these improvements, has been done by Europeans." There is a spark of truth in that as you know, since I am of French descent and a born German, but I did my research work in the matter of my improved electric incandescent lamps of three different classes as the American that I am and have been for the last forty years.

The priority question in the premises is thus made an international question, between Welsbach, Siemans, Kuzel, Just, Haneman and other followers of Welsbach on the one hand and your obedient Cazin on the other.

With Welsbach, who has never been heard or seen in the proceedings, conducted by the Welsbach Light Company of Gloucester City, N. J., as his alleged assignees, the fight has been on as to such priority. And the history of that fight in the form of interference proceedings No. 24,614 is well told in the testimony, taken in the case on my side and supported by documentary proofs, no testimony on the other side ever being presented except a chemist's expert opinion, on matter in fact not involved in the case, of which testimony I offer printed copy to those who feel sufficiently interested to obtain one of the few copies left in my hands.

Amongst many other pieces of evidence the testimony offers an original letter, directed to Cazin, dated January 5, 1898 by the managr and chemist, Waldrow Shapley, the same man who it was proven to have been sent to Vienna to obtain (on May 23, 1898), an assignment for the said company of an application, which it had prepared in New York for Welsbach, and after obtaining his signature filed on January 31, 1898, which original Shapley letter is a receipt for a copy of Cazin's application of October 15, 1898, the specification of which discusses both the Cazin Lamps No. 1 and No. 2, as well as the electrolytic method of filament plating and the new method of hermetical wire-sealing.

I challenge all alleged inventors of anything in the line of metal filaments to prove priority of their alleged inventions to my official disclosure thereof, as now in the files of the United States patent office, notwithstanding, that it took 11 years to obtain my first fundamental patent, and notwithstanding that all technical periodicals, with the exception of the *Central Station* and THE ILLUMINATING ENGINEER, have faithfully followed up the order of their advertising patrons, to apply for the last ten years the policy "des Todtschweigens" to the old man Cazin and his electric lamp improvements, a policy, of which the German technical periodicals are absolutely innocent.

Very sincerely and respectfully,

F. M. F. CAZIN.

1108 Bloomfield St., Hoboken, N. J.

Illuminating Engineering Society

ADDRESS OF CHARLES PROTEUS STEINMETZ, DELIVERED BEFORE THE NEW YORK SECTION, DEC. 14.

LIGHT AND ILLUMINATION

(Unofficial report, by our own stenographer.)

The subject of tonight's discussion is Light and Illumination. When dealing with this subject, the subject with which our society has to deal, we are at a disadvantage, compared with the other branches of engineering, such as the transformation of electrical power into mechanical power, or the transformation of chemical energy into mechanical power, as in the case of a steam engine; we are at a disadvantage in that we have not to deal strictly with problems of applied physics, but are on the borderland between applied physics, that is, engineering, and physiology. Light is not a physical quantity, but is a physiological effect exerted on the human eye by certain radiations. There are different forms of energy convertible into each other, as magnetic energy, electric energy, heat energy, mechanical momentum, radiating energy, etc. The latter, radiating energy, is a vibratory motion of a hypothetical medium, the ether, which is transmitted, or propagated, at a velocity something like 188,000 miles per second; and this is transverse vibration, differing from the vibratory energy of sound in this respect, that the sound waves are longitudinal, that is, the vibration is in the direction of the beam, while the vibration of radiation is transversely.

Now, radiating energy is derived from other forms of energy; for instance from heat energy, by raising a body to a high temperature we find that this heat energy is converted into radiation and issues from the heated body, as in the case of an incandescent lamp filament, as a mass of radiations of different wave lengths, i. e., different frequencies, we get all kinds of frequencies from very low frequencies, that is, only a few millions of cycles per second, up to frequencies many times as great. Now, we can get, if we desire, still very much lower frequencies, as electric magnetic waves, such as a radiation sent out by an oscillating, or alternating current; but the radiations which we get from heated bodies are all of extremely high frequency, compared with the electric current; at the same time they cover a very wide range of frequencies, over many octaves; and from all this mass of radiations, somewhat less than one octave can be perceived by the human eye as light.

Light, therefore, is the physiological effect exerted upon the human eye by a certain narrow range of frequencies of radiation. There are frequencies lower than those visible to the eye, and frequencies higher than those visible to the eye. We frequently speak of those lower frequencies than the visible ones as radiant heat, and of those frequencies higher than the visible ones as chemical rays. We must, however, understand that there is no distinction between them. There are no heat rays differing from light rays or chemical rays.

Any form of energy when destroyed must give rise to an exact equivalent amount of some other form of energy; however, if we destroy radiant energy by intercepting the beam of radiation, as by interposing an opaque body in its path, then the energy of radiation is converted into some other form of energy, usually into heat. This means that any radiation absorbed produces heat, and the amount of heat produced merely represents the amount of energy which was contained in the radiation. If the radiation contains a very large amount of energy, when intercepted

the heat may be sufficient for you to feel by putting your hand in the beam. If the amount of energy is less, it may not be possible to feel it, though with a sensitive instrument, such as a bolometer, we may still be able to measure the heat; but that does not mean that the radiations which are visible are different from those which are invisible, nor that radiations which are invisible can be called radiant heat; they are no more heat than the mechanical momentum of a flywheel is heat, because when we destroy it it produces heat. If we consider the infinite range of radiation issuing from heated bodies, we find those rays which are of lower frequency than the visible rays, will be felt as heat, because they contain a very large amount of energy.

The rays which are visible represent very little energy—it just happens so,—and therefore they do not contain as much heat. For instance, in the case of a hot steam boiler, although we get no light, we can perceive the radiation from it by the heat which it produces when intercepted by our hand held near it. We do not feel the radiation as heat which issues from the green light of the mercury lamp, merely because the amount of radiation in the latter is infinitely less than the amount of energy in the radiation from a hot steam boiler; but while it is less in the former case, it happens to be of that frequency which effects the eye, and therefore is visible. It results from this that when we speak of cold light, that does not mean that it is different from hot light—from the light, for instance, given by a hot coal fire, where we feel the radiation as heat; it merely means that what is usually called cold light is radiation containing to a very large extent rays of the visible frequencies, and less energy outside of the visible range, i. e., containing very little total energy, so that the energy when destroyed, i. e., converted into heat, cannot be observed by the hand easily, but requires more delicate methods of determination; while a very inefficient light, such as a coal fire, for instance, which gives most of its energy of radiation as invisible low frequency rays, and very little visible radiation, we feel—that is, we feel the heat produced by the interception of the energetic low frequency rays.

As stated, then, there is no essential difference between heat waves and light waves; but any radiation that is converted into any other form of energy, such as the so-called chemical rays, ultra-violet light, and the x-ray, when intercepted also produces heat just the same as red light, only very much less heat, not enough to be perceptible to the touch, because the total energy of the ray happens to be very much less. Our means of producing radiating energy are able to produce high intensities of radiation only for very low frequencies such as the invisible ultra-red rays; we are not able to produce anywhere near the same intensity of radiation for higher frequencies, especially very high frequencies; so also, when we speak of ultra-violet, or short waves, or other high frequency waves, as chemical waves, that does not mean they are the only waves which have a distinctive character in producing chemical action. Any form of energy can be converted, if we know how, into chemical energy; the long ultra-red wave just as well as the short ultra-violet wave. It just happens that those chemical compounds which are easily split, such as silver salts or salts of gold and platinum, are especially affected by the ultra violet and violet rays, so that we observe the chemical action of these rays, but do not observe so well the chemical action of other rays.

It is obvious if we intercept and destroy radiation in order to convert it into other forms of energy, if the energy is only high enough, we get high temperature, or high chemical action. By the mere effect of temperature we also may get chemical action by what probably is

some kind of resonance phenomena. The particles of a body, say the atoms of the molecules, naturally must have some rate of vibration of their own. If, then, a radiation impinges upon them which is of a frequency of the same magnitude as the inherent rate of vibration of the atom, the vibration of the atom must rapidly increase in intensity from resonance until it breaks away from the molecule, and the chemical combination is thereby split up. The inherent frequency of oscillation of the atom seems to be about of the same magnitude as the visible radiation, or rather a little higher frequency; that is, if the atoms of the metals or other compounds are caused to vibrate freely, as under the influence of an electric current in the arc, then we get radiation of the frequency inherent to the atom. The general tendency is then toward the violet or short wave end of the spectrum. If we assume that the wave entering the mass of the silver salt is such as to give a rate of vibration about of the range between the violet and ultra-violet, it is easy to understand that this frequency of light will split up the silver salt by increasing its vibration through resonance, and the shorter or longer waves will not have any effect, or an effect in much less degree; so that it may be a mere incident that these chemical compounds in which we observe the chemical action of radiation just happen to be sensitive to the violet end of the spectrum. Now, it is a fact with other chemical changes as in the formation of ozone from oxygen, that is, the splitting up of the oxygen molecules and reforming of the ozone molecules from the atoms, chemical action does not take place in the violet or ultra-violet, but requires frequencies very much higher,—about the highest frequencies which the mercury arc at low temperature gives. Possibly, since the oxygen atom is so much lighter than the silver atom, its frequency of vibration is much higher, which means that resonance effects, and destruction of the molecules take place only with the much shorter wave lengths of radiation, i.e., much higher frequency.

Inversely, it seems that those frequencies which are chemically active in organic life, and which are absorbed from radiation by plants, giving the chemical action utilized in building up the growth of vegetation, are at the red end of the spectrum, not at the violet end. It appears that the red and ultra-red rays produce growths of plants and chemical activity which we call life, while the violet and ultra-violet kill. This can be explained if we consider chemical activity as a resonance phenomenon, because metabolism of protoplasm is based on the unstable structures of carbon compounds. We have not here atoms compounded with each other, but groups, mere chains and links, which are of a larger mass and therefore have a much lower rate of vibration, and should be expected to respond to the lower frequencies of red light; while the violet and ultra-violet light will not split up the organic matter into groups which can recombine, forming complex bodies, representing the changes in life, but will split it up into atoms that remain in that condition, which means death. It can thus be easily understood that the chemical activity of different radiations may be different; the chemical activity of long rays gives life to vegetation, and the short waves may mean death. One splits up the carbon groups, the other carries destruction of the atom with it.

The distinction between heat waves, chemical waves, and light waves is not a physical distinction; they are all radiating energy of the same character, differing merely in wave lengths, the visible range being somewhat less than one octave, rather at the upper end, at the higher frequencies which are difficult to produce. This makes the problem of investigating and dealing with light difficult for the engineer, because it is not a physical quan-

tity which can be measured accurately, as in the case of power, or velocity, but is a physiological effect. We can, indeed, measure very accurately the total energy of radiation from a heated body; but the total energy of radiation is not light, since only a very small part of it is visible. We may go further, and say that if we split up the total radiation issuing from a hot body, as an incandescent lamp filament into different wave lengths, or different frequencies, as, for instance, when we resolve the total radiation by putting a prism into the rays in order to separate the different frequencies, and then collect the total radiation within the visible range by a lens or other means, and measure that, or, still simpler, if we interpose in the beam of radiation some medium which absorbs the invisible long rays and invisible short rays, but which transmits all, or nearly all, of the visible rays, as a glass of water, we can easily measure the energy of the visible radiation and compare it with the total energy in all the radiation.

This would give a physical measure of the efficiency of producing visible radiation; but it would not be a measure of the efficiency of producing light, since, unfortunately, the different wave lengths of visible radiation are very different in their physiological effect. A given amount of energy as visible radiation giving the effect of green light represents an entirely different amount of light, i.e., many times a greater physiological effect than the same amount of energy as red rays, or rays of the wave lengths which give the impression of red light. This means that the physiological effect of mechanical energy within the visible range is a function of the wave length, and varies with the wave length, that is, with the color. This is obvious if you follow the range of frequency from low to high. You see that energy radiating at low frequency represents no light whatever, i.e., has no physiological equivalent; it is invisible. When you come into the visible range it represents physiological effect, and is the equivalent of light. Therefore, when you pass from the invisible range into the visible, you see the physiological equivalent must pass from zero to a finite value, which must necessarily continue to the other end of the visible range. As you go into the visible range you reach the maximum at about the middle, in the green and yellow, and decrease again down to zero at the violet end of the visible rays; beyond that in the still higher frequencies, the physiological equivalent of energy is zero again; inversely, if we take the mechanical equivalent of light as a minimum in the middle of the visible range, where one candle power of light represents the lowest amount of energy, and suppose it to increase toward the end of the spectrum, or visible range, it would reach infinity at the end, because at the end of the visible range there is no more light; then, the infinite amount of energy would not produce any more scintillation than one candle power of light. Now, this means, in plain language, that the efficiency in light production is a function of the wave length, that is, of the color, and that the maximum is in the middle of the spectrum; a given amount of energy gives the largest amount of light measured in candle-power, if the energy is in the form of radiation of the frequency corresponding to the middle of the visible spectrum.

Unfortunately, the physiological equivalent of power, or the physiological effect of light, varies not only with the wave length, but also with the absolute intensity. Suppose we undertake to compare red, yellow and green lights, or any lights of different colors. We meet the great difficulty of how to compare them. We want one candle power in light, as red, yellow, or green. We cannot compare them directly since we have no physical measure of light; we cannot measure it physically, because

it is not a physical quantity, but a physiological effect. We compare different lights by comparing them with a standard candle, but a standard candle has a certain color, and we cannot compare it exactly with any other illuminant which has a different color; but if the color is the same we can get an approximate comparison by observing when the two lights of similar color are of about the same intensity; thus, we can observe the two sides of the photometer screen, and get a fairly accurate measure of the relative intensity. But where we have a red and a green light we cannot say, with one side of the photometer red and the other side green, that the two intensities are equal; there is no comparison. We see in the beginning that we cannot say that a certain amount of red light, or a certain amount of green light, represents the same number of candle powers, photometrically; but, after all, if we go one step further and consider that light is used for illumination, that is, to see by, that gives us a rough comparison; we can take a red light and a green light and observe at what distance from the two lights we can read with the same convenience, or read the same kind of print; or, to measure more exactly, get the maximum distance at which we can just read a certain size of print, by both lights, which means that at this distance the two illuminations are the same, and the two lights will have an intensity in inverse proportion to the squares of the two distances. In this manner you could compare lights of different color.

Necessarily, the comparison has not the accuracy of photometrical comparison, but cannot have, because they are not physical quantities that we are comparing, but only effects on the eye. Different observers may have different personal constants. The eye of the one may be more sensitive to green, and the eye of the other may be more sensitive to red, and therefore the comparisons may be very different. However, these individual differences are not so very great, and different observers, even with widely different colors of light, do not differ so very much from one another; so that we can get a comparison of intensities of different colored lights, or express their intensities in candle power, approximately, by some such method, i. e., by observing the illumination which they produce. We find, however, if we take the same two lights, and assume that they are of the same intensity, i. e., at 10 feet distance we can just see the same size of print; if now we take a very much larger print which should enable us to go a greater distance from the light, we will find that the two lights are no longer equal, but that the green light is much brighter than the red. If we take a much smaller size of print and get nearer to the lights, the red light appears brighter; or, more roughly speaking, if we have a green light and a red light, which at a certain distance appear equally brilliant to the eye, then when we get nearer to the two lights the orange-red light will appear much brighter than the green, and when we go further away the green light will appear brighter; and at still further distances we will still see the green light when the red light is almost invisible. The sensitivity of the eye for green light is very many times greater than for red light, or, rather, the ratio of sensitivity for green compared with red is greater for faint illumination than for intense illumination. If we desire to express a light in candle-power for different colors it is necessary also to give the distance or intensity of illumination at which we have observed; in other words, light in the middle and the short wave end of the spectrum is very much more prominent and gives better illumination, where the total intensity is low; while the long wave or low frequency of the red, orange, and yellow light gives a much more brilliant effect at high intensity.

This is of importance for the illuminating engineer, because you see, where you desire to get very high effects, as in decorative lighting, or in advertising, you get much better results from the low frequency end of the spectrum, from the orange and yellow light; whereas, when you desire to get low intensity of illumination, as in street lighting, you get a much better result from the short wave end, or the middle of the spectrum, from the greenish-yellow of the Welsbach gas light and the bluish-green of the mercury lamp, which gives you a better result than the orange-yellow of the old incandescent lamp. The white light of the arc gives you a better result than the yellow of the incandescent lamp. All of these features have not been of importance until a few years ago, when the available sources of light were all approximately of the same color, were all from the orange-yellow, yellow, yellow-white, whitish-yellow and white; from the gas lamp, kerosene lamp and tallow candle of orange-yellow color, to the yellow incandescent lamp and the yellowish-white arc and the yellowish-white sunlight, to the white diffused daylight. We had a fairly limited range. It is only in the past few years that illuminants of high efficiency have been brought out, which give marked and decided color differences in available units of efficiency, as the greenish-yellow of the Welsbach gas lamp, the bluish-green of the mercury lamp, and the orange-yellow of the flaming arc, and hence these questions are increasing in importance.

This brings us to the consideration of the method of producing light. Now, until a few years ago, until the development of the Welsbach gas mantle, practically all methods of producing light were based on incandescence, i. e., by impressing energy on a solid body, either the chemical energy of combustion, or electric energy in the incandescent or carbon arc lamp. In the latter case, the temperature is raised to such a high value that amongst the total radiations issuing from the heated body a certain very small percentage appears within the fraction of an octave as visible light. With increasing temperature of the radiating body the average wave length of radiation decreases, i. e., the average frequency of radiation increases and so approaches nearer to the visible ray; although still, at the very highest temperature which can be produced, the average wave length of radiation is very far below the visible. It still means that the higher the temperature reached by an incandescent body the higher will be the average frequency of radiation and the larger the percentage of the total energy of radiation that is within the visible range as light. So that the problem of efficient light production by incandescence is the problem of reaching as high a temperature as possible in the luminous body. In the gas flame and the kerosene lamp, this temperature is the temperature of combustion, rather limited; in the incandescent lamp it is limited also. In the latter case the temperature which can be reached is limited by self-destruction of the incandescent body. The highest temperature probably which it can reach is the boiling point of carbon, in the crater of the carbon-arc lamp, and therefore that would give the most efficient incandescent light. It is incandescent light, because the arc flame, or the vapor-conductor, does not appreciably contribute to the amount of light issuing from the arc lamp. Very much lower, necessarily, is the temperature of the carbon filament of the incandescent lamp.

The problem is to find materials which can stand very high temperature; to increase the temperature of the gas flame, as well as of the incandescent filament. We have increased the temperature of the gas flame by using a gas of higher chemical energy, as acetylene. The acetylene flame is white; the ordinary gas flame is yellow. We have increased the tempera-

ture of the carbon filament by replacing the carbon with some more refractory material, such as tantalum, osmium, tungsten, etc., and so get a higher efficiency. We can increase the temperature of the gas flame by increasing the rapidity of combustion. We can increase the temperature of the carbon filament in the incandescent lamp by increasing the energy applied, but if we increase the temperature of the carbon filament it is more rapidly destroyed. To increase the temperature of the gas flame by more rapid combustion—as has already been done—we do not have the gas issuing from a round hole, but from a flat slot, so as to give a larger surface to the flame. If we go still further and mix the gas with air, we get a still higher temperature; but if we get a more rapid combustion, that destroys the incandescent body, because the incandescence of the gas flame is due to light given off by the heavy hydro-carbon particles floating in the gases of combustion, and by increasing the rapidity of combustion we consume them at such a rate that, while they should give more light, they do not last long enough to give it. We could increase the efficiency of the gas flame by mixing the gas with air, as in the Bunsen flame, but we have to insert a luminous body of some other material, not carbon produced by the dissociation of the gas, because the carbon is instantly consumed. We can do it by a skeleton of platinum wire which can be set glowing. We cannot reach very high efficiencies, since most of the energy is outside of the visible range. We can imagine the efficiency of light production if we could find an incandescent body which would not radiate in the same manner as the carbon filament or the average so-called "black body," which would give an abnormally low small radiation of low frequencies but which had an abnormally high quantity of high frequency radiation within the visible range. Such a body may be said to give selective radiation, because the distribution of energy in the spectrum amongst different frequencies of radiation is not the same as it would be with an ordinary black body of the same temperature. A body which should give an abnormally low radiation in the visible range, or abnormally high in the invisible range, would be an abnormally inefficient light producer; but if we could find a body giving abnormally high radiation of short wave lengths, in the visible range, and abnormally low radiation of long waves at low frequency, it would be an abnormally efficient incandescent body. Such bodies exist, and the enormous progress in gas lighting made by the introduction of the Welsbach mantle is based on selective radiation; the oxides of which it is composed do not radiate the same range as the black body, incandescent carbon, would do, but give an abnormally large amount of visible rays compared with the invisible rays; that is to say, they give a larger percentage of high frequency light rays compared with the low frequency invisible rays. Now, possibly some of these highly efficient metal filaments, like the tungsten filament, also owe their high efficiency to selective radiation.

When we come to selective radiation we must understand what is meant by it, otherwise we may very carefully investigate and conclude that the Welsbach mantle or the tungsten filament owes its high efficiency to some other cause than selective radiation. We may prove very conclusively that selective radiation is not the cause of the high efficiency, and some one else can prove just as conclusively that it is due to selective radiation. It all depends upon what you define as selective radiation. The same thing is true if you look over the literature of the subject. One observer writes a paper and claims it is not selective radiation which gives this efficiency; another claims it is selective radiation. It is the same, as some of the older men among you

will remember, as the controversy which was carried on for many years on the question of the counter-electromotive force of the arc. It was proved scientifically by many of the writers that the arc has no counter e. m. f., while others can prove with equal conclusiveness that there is a counter e. m. f. in the arc. It depends on what you define as counter e. m. f. In the same way, the solution of the question of selective radiation depends on what you define as selective radiation. If you define as selective radiation any radiation in which the intensity is distributed in the spectrum differently from that of the theoretical black body, then the Welsbach mantle has selective radiation. If, however, you define selective radiation as the radiation of a body which gives a line spectrum, i. e., which gives abnormally low intensities, within certain narrow ranges, which gives absorption bands and bright bands in the spectrum, then the Welsbach mantle does not give selective radiation, because it does not show absorption bands or bright spectrum lines.

When you read any discussion on selective radiation you first have to find out what the other person means by selective radiation. If you produce a vibration of some body, as for instance, set a violin string in vibration, you get a definite pitch in tone, or rather a number of pitches; a fundamental frequency and secondary frequencies. In an incandescent lamp filament you do not get a definite pitch, or a definite frequency of vibration, that is, definite wave-lengths of light, but an indefinite number of frequencies. The reason is that we have a solid or liquid body in which the vibrating atoms are sufficiently close together to interfere with one another. If we could set a body in vibration in which the vibrating particles, atoms, or molecules, are so far apart as not to interfere with one another, as gas at low pressure, so that they can execute their own rates of vibration, the light from such a body would not consist of radiations of all wave-lengths, but of a few definite wave-lengths, or lines of the spectrum. Thus, incandescent sodium vapors give only one kind of light, and in addition thereto a number of ultra-red and ultra-violet rays. Since the spectrum of light is based on the interference of vibrating molecules, it is easy to understand, and we bring the atoms or molecules closely together, interference begins, and we find the line spectrum disappearing, the lines getting more confused and blurring into each other. Therefore, we see in the mercury arc spectrum, which is a low pressure gas, a small number of definite, sharply defined lines; while in the calcium or the carbon spectrum we get the largest number of lines blurring into each other. So also we get the white spectrum of the magnetic arc.

Where we set gas or vapor into vibration, it vibrates at its own frequency, independent of the temperature. It gives a certain vibration, and it is merely a question of the character of the material whether a very large percentage of the total energy of radiation will happen to be within the visible range or outside the visible range. Temperature does not come in, because frequency of radiation is no longer a function of, but independent of the temperature; in general it is the same. Sodium vapors will give the same frequency of radiation, the same yellow lines whether the sodium vapor is at low or high temperature. Some substances may increase in frequency with increase in temperature faster than others, and the color of light may change with the temperature, from yellow to white or blue, or from green toward white, or toward red, as the mercury light does, with increasing temperature; but that is merely a characteristic feature of that particular body, and not a general effect of temperature,

The possibility therefore exists of finding materials which, when energized in the state of vapor or gas, will

give a spectrum having a large amount of energy in the visible range, thus giving an efficiency of light production far in excess of that available by incandescent lamps. So far the only metals which have been found which have these characteristics are mercury, calcium, and titanium. These three metals give spectra which contain such a large percentage of the total radiation, that the amount of light measured physiologically in c. p. is far in excess of that which possibly could be produced by incandescence, even with the assistance of selective radiation. Thus far these conditions are realized only in the mercury arc, the yellow flaming carbon arc, the tungsten arc, and the white titanium arc, which are of such very high efficiency as to be of higher magnitude than any incandescent light. Even if we take only these three illuminants we have quite a color scale, comprising all the colors from orange-yellow, which is about the longest wave lengths we could use, to yellow and yellow-white in the acetylene flame and the tungsten filament. Then we have the greenish-yellow of the Welsbach mantle, by selective radiation. We have the blue of the arc, and the yellowish-white of the carbon arc, as well as the clear white of the titanium arc, the yellowish-white and orange-yellow of the calcium arc, and the bluish-green of the mercury arc. Each of these can be modified. We can modify the titanium arc, giving all colors from yellow-white to bluish-white, by the addition of other materials which give either a yellowish or bluish spectrum. We can modify the yellow calcium arc, and the orange-yellow of fluoride of calcium down to yellowish-white by using calcium borates. We can modify each color over a certain range, and we can get pretty nearly any color scale, with the exception perhaps of a clear blue and violet; but no means has been found to get approximately the same efficiency in those lights as in the other colors of lights. This feature naturally makes the effect of color and the variation of physiological effect with the brilliancy of illumination, of more importance now than years ago, when the only method of producing colored light was by the absorption of any desired color.

But after all, it is not light we want, but illumination. It is not the amount of visible rays issuing from the source of light, but the amount of light which reaches the objects we desire to see; that is, the illumination produced by the light, which is of importance. That is the mistake which the gas industry, as well as the electric lighting industry, has made for many years. They have endeavored to produce light, and entirely left out of consideration the fact that light is not the only important thing, but in addition to the light, and of the same importance, is the utilization of the light so as to get illumination. This feature is of equal importance with the production of the light, but has been usually left to the tender mercies of the decorator to place the light-sources wherever he thought they would look artistic, regardless of the illumination produced. If you will look around you will find in almost all cases of artificial illumination that the light-sources have been arranged, not for the sake of getting efficient illumination, but haphazard, in any kind of way. To overcome this practice, as we all know, is the object of this society. This problem of the production of light and the physiological effect produced by the light on the eye, requires careful study, just as any other engineering problem. It is of importance for us to consider not only the amount of light issuing from the flame, but the amount of light which reaches objects to be seen by the illumination.

The demands of illumination are mainly of two classes, general illumination and local, or concentrated, illumination. Many cases require general illumination, like this meeting room, where the desire to see equally well, to get the same intensity of illumination throughout the whole illuminated area, is considered; so in

the draughting room, the school room, the hall of a house, and the streets of a city, general illumination, uniformity, and a fairly high intensity are required; very high intensity in draughting room, to be able to do careful work everywhere; relatively low intensity in the streets of a city. The lighting of a city street is usually very far from uniform, but that does not mean that the problem of street lighting would be solved best by uniform distribution; it merely means that street illumination is relatively less uniform, from the necessity of the case. In other cases we require concentrated lighting; in domestic lighting, in the dining room, in the living room, we desire light mainly on the table where we work, eat, read, etc. The general illumination of the room is of lesser importance; is not needed to any extent, and is frequently undesirable, because a room with a very low brilliancy of general illumination frequently is considered more homelike, especially by the feminine part of the human race. Again, general illumination in another place may be directly objectionable, as in the sick room. Most cases require general illumination and local illumination; general illumination of moderate intensity, and far more intense local illumination, as on the desks in an office, or over the reading table in a library. In such cases we frequently get along with the general illumination by making it very much more intense, but that is uneconomical, and to some extent objectionable on account of the blinding rays.

Again, in producing illumination we can use either direct lighting or indirect lighting; the rays issuing from the source of light may either pass directly to the illuminated objects, or they may pass to a reflecting surface, and from that surface to the object; or they may be passed through a refracting body, as the frosted incandescent lamp globe, or opal globe of the arc lamp, and so reach the illuminated object. In general, it is obvious that any method of indirect lighting by refraction or reflection wastes a considerable amount of light. We lose light by absorption; that is, the total amount of light which reaches the illuminated object must necessarily be less with indirect lighting than with direct lighting, with the same amount of light. We can have indirect lighting either by reflecting or refracting by some attachment to the lamp, a reflector or a Holophane or frosted globe, or by deflecting the light from the ceilings and walls of the rooms on the objects to be illuminated. In the latter case it is obvious that if the surroundings are white, the white walls will give a high efficiency of reflected light. Any one can observe that the same source of light in a room with white walls will give several times the intensity of illumination which will be given in a room with black and non-reflecting walls, from the same source of light. That means the total amount of illumination is increased several fold by reflection from white walls. In a draughting room, or schoolroom, we must have as light walls as possible, to get the best efficiency of illumination.

It is not always feasible to have light walls, especially when we come to machine shops or foundries, and in other places where the walls do not remain white. The walls always change to some darker color. The question is, what color do these walls assume? The color of everything which is changed by age is due to either iron or carbon. If you look around you will find in most cases it is the result of iron, reddish-brown, but it sometimes is due to carbon, and then the shade is a brownish-yellow. The color which all materials assume is either the one or the other. Both are in the long wave or low frequency end of the spectrum. Where you have to count on reflected light and desire to get the benefit of reflected light from walls which cannot be kept perfectly white, then the source of light giving long waves and low

frequency on the yellowish tinge will be more efficient than any other. This is very marked when you compare the mercury arc lamp with the flaming carbon arc lamp. The illumination given by the mercury arc lamp in the draughting room will be very satisfactory. The same illumination in a foundry or machine shop will be less satisfactory, and you will notice there the corresponding absence of reflected light; the walls and ceilings all gradually assume a color which is rich in red and yellow, and therefore reflect very largely—even the black-begrimed walls of a blacksmith shop will reflect a considerable amount of light—the orange-yellow rays, but practically no light of the bluish-green of the mercury arc. Therefore, the shade of color of the illuminant may be very essential in getting efficient illumination. Again, in the interior of a city, the walls usually have a reddish-yellow color. In that case white or yellowish lights are superior. When you are outside of a city, the greenish-yellow of the Welsbach lamp, or the bluish-green of the mercury arc, gives you a much larger amount of reflected light from vegetation than the yellow of the incandescent lamp. Vegetation absorbs the long waves, low frequency radiation, so that with the yellow source of light there is practically no reflection from living vegetation, but only reflection from dead vegetation; therefore, in the light of the incandescent lamp all vegetation appears very poorly, and you see the dead parts very prominently, while the reverse is the case where the light is deficient in the red and yellow, and rich in the green and blue.

Again, it is not the amount of light which reaches the object illuminated which is of importance, that is, not the physical intensity of illumination, but the amount of light which reaches the human eye from these illuminated objects. With the same intensity of illumination, the same amount of light reaching the illuminated object, of the same color, the amount of light entering the eye may vary widely with the opening or contraction of the pupil. The eye is automatically self-adjusted for intensity of light, which is the reason we see equally well with sunlight as with the light of the full moon, although the former is many thousand times greater in intensity than the latter. The eye can accommodate itself to intensities varying within a range from one to several thousands. This it does partly by the fatigue of the nerves of vision, but mainly by the contraction or opening of the pupil. This is undoubtedly a protective device developed in the human race. Thus, if we have in the field of vision a source of light of high intrinsic brilliancy, the eye protects itself by contraction of the pupil, and will receive very much less light in the field of vision where we want to see objects, than if the source of light were taken out of the field of vision. By eliminating the source of light from the field of vision and eliminating the contraction of the pupils resulting from the high intrinsic brilliancy of the illuminating body, we get actually a very much larger amount of light into the eye with the same amount of light striking the illuminated object; that is, we get a higher physiological efficiency. Even with a much less amount of light reaching the illuminated objects, we still get more light in the eye. That means if we reduce the intrinsic brilliancy of the illuminant by indirect lighting, or by diffusing the light, we may lose a considerable amount of light, that is, actually get a considerably reduced quantity of light on the object which we desire to see, but still get a very much larger amount of light from these objects into the eye, because the eye is open further and can receive more light. It follows from this that in efficient illumination, it is of foremost importance to arrange the illuminant so as not to have excessive intrinsic brilliancies in the field of vision when looking at the objects we desire to see.

That means that the proper field for the illuminant is outside of the field of vision; or where you cannot get it out of the field of vision, to reduce its intrinsic brilliancy by diffusion and thereby actually get a much higher physiological effect. That is the reason for indirect lighting.

We may have a very large amount of light thrown on any object in a room, but get very little light in the eye, because the eye is fatigued. It appears, however, that this automatic protective faculty of the eye, developed through the ages, is a protection, not against light, but against energy. Apparently the eye is protecting itself against the energy of radiation, not the physiological intensity; and since the energy of radiation is mainly in the ultra red, in the long waves, the frequency which causes its reaction is the frequency on the long wave end of the spectrum, the red and yellow waves; these make the pupil contract and cause the self-protective action. This action is much less if the green and blue rays are in evidence. That is the reason the eye does not react on the mercury lamp to any great extent. A green light, like the mercury arc or Welsbach lamp, can be in the field of vision to a much greater extent without giving the contraction to the pupil and reducing the physiological effect. That is of importance in places where you cannot take the light out of the field of vision, as in street illumination, where you must have all the sources of light along the street and must see them. By cutting off the red end of the spectrum you eliminate the contraction of the pupil, and get the full benefit of the light between the illuminants; while with the low frequency source of light, as the incandescent or arc lamp of old, you do not get the benefit; the physiological effect of illumination by a green illuminant in such cases is superior to that from a yellow illuminant.

A light devoid of red and yellow rays is at the same time the safest and most harmless, and also the most harmful. It is the safest and most harmless, and gives the most uniform illumination, if its intrinsic brilliancy is sufficiently low to be below the danger limit of energy of radiation; but is harmful if above that, because the eye does not protect itself against it. These lights have not existed throughout all the ages while this protective action of the eye was being developed, which accounts for this rather contradictory effect that has been observed, viz: that green or blue light, even the Welsbach mantle, is a very good light to work by, being superior to the yellow kerosene lamp; at the same time there is some suspicion that it is harmful to the eye, which may well be where it is of very high intensity, so that the automatic action of the eye is not sufficient to protect. Where you use such sources of light you can get the benefit of the contraction of the pupil, but it devolves on you to arrange them so as not to get the harmful effects against which the automatic protection of the eye fails. That means all these lights are superior for illumination if they have low intrinsic brilliancies, but somewhat questionable if they have extremely high intensities.

It is not even the amount of light which enters the eye which is of importance in illuminating objects, but the difference in the amount of light. If in the illuminated area the light was of uniform intensity, and everything was of the same color, we would see nothing but a glare of light. Seeing takes place by a difference in color, and difference in intensity. Difference in intensity includes shadows. Shadows are the essential feature in seeing things. Considering, then, seeing by shadows and seeing by color differences, you observe that by this feature we can distinguish the illumination, and divide it into directed illumination and diffused illumination; diffused illumination, in which light comes in all directions approximately uniform and in which shadows do not

exist; and directed illumination, in which shadows do exist. In some cases shadows are objectionable, and in other cases shadows are necessary for clear distinction; diffused illumination in the latter case would not be satisfactory. Where it comes to seeing different colors, it is obvious that where definite color conditions are required, you can intensify the sharpness of vision by selecting the color of your light best suited to bringing out the colors desired. Where the color conditions you want to distinguish are those due to age, iron and carbon, then the light which is deficient in red and yellow, which therefore shows the colors given by iron and carbon, gives a much sharper distinction; the mercury lamp will therefore show blemishes and dirt much more pronounced than a white light. Again, the sources of light which are very rich in red and yellow rays will show these colors due to iron and carbon very much less, and therefore will show blemishes or a slight amount of dirt very much less; therefore, where the color distinctions are due to these two most prominent elements, in the yellow light their appearance will be greatly softened, while under green light they will be made harsh and sharp. If you desire to soften effects, as in a ballroom, it would be fiendish to use a mercury lamp; but where you want to search out a spot that is soiled, it would be very wrong to use a dull, yellow incandescent or gas flame, but rather to use the green Welsbach light, gas mantle, or the bluish green mercury arc, which will give a much better effect. When you desire to see all colors in about the same relation as daylight, you obviously desire a white light. It is quite important for the illuminating engineer also to select the shade or color of the light and study the requirements of each case which comes into his charge. It would be just as wrong in one case to use an incandescent lamp, where the mercury lamp would be better, as to do the reverse.

We have to consider also between general illumination and local illumination, between direct illumination and indirect illumination, and between directed illumination and diffused illumination. These three different classes or distinctions to a certain extent overlap. It would be very wrong, however, to mistake them, and a very serious mistake in the design of a system of illumination can very easily be made; for instance, in the case of general illumination vs. diffused illumination, the problem may be to get uniform intensity all over. You can get that by distributing a large number of small units all around the cornices and reflect the light from white walls and ceilings and get a very diffused illumination; or you could get general illumination, where the intensity of illumination all over is the same in a moderate sized room, from one source of light by using one of these sources of light with a holophane reflector, which gives the proper distribution; or you could get light from any other sources, merely controlling the distribution cure of the light so as to get uniform distribution. The former will give diffused light, the latter directed light. You will get the same intensity of illumination all over the room, in both cases; in the former cases no shadows, in the latter case absolutely black shadows. Probably in the former case for domestic use the lighting will be unsatisfactory and trying to the eyes, because you do not see well, you do not have any shadows, and objects around you are not so distinct, because you lose the distinguishing feature of the shadow. In the latter case, with the directed lighting from one source, the lighting will be unsatisfactory, because you get very dark shadows where you can not see anything, and the eyes will be made tired by trying to see in the very dark shadows.

You have to consider how much directed light you want and how much

diffused light you want. In some cases you may desire only diffused light. In the general lighting of the draughting room you do not want any directed light; you must have no shadows, because if the ruler casts a shadow, mistakes may be made. That is extremely annoying, and by trying to avoid a mistake it is tiring to the eyes. There you desire to see only by differences in color and in the intensity, and not by shadows. You may get very satisfactory illumination from many small units, or by indirect lighting, reflected light from white walls and ceilings, or you may get very satisfactory illumination from a few units properly distributed to give uniform intensity all over, but giving no reflected light. If you desire general illumination equal in intensity all over, you must have directed illumination so as to see all the shadows.

The draughting room illumination will not be suitable for the foundry. You need a number of units of light to give directed illumination, but you must not go so far as to be able to see in the shadow; you must have some diffusion, or overlapping of the different beams of light, and yet if you take a satisfactory foundry illumination and put it in the draughting room, even if the intensity was satisfactory, it would be entirely wrong. It is not merely the distribution of the intensity of the light, which is essential, but also the character, whether diffused or direct light.

In different lighting problems you meet the question of concentrated or general illumination, directed or diffused illumination. In domestic lighting, in the interior of the room, by reflected light on light walls we get a high intensity, we increase the illumination several fold over an ordinary source of light, such as the incandescent light and gas flame, and the light is scattered in all directions. Still the illumination would be unsatisfactory and tiring to the eyes. We all know in the home if we have a light with white walls it is not as agreeable as a light with darker walls. We say we have too much light. We do not have too much light, because we do not have anywhere near the same amount of light as we get during the daytime out of doors. We have too large a percentage of diffused light. The intensity of diffused light is too great as compared with the directed light. We lose the shadows and that is tiring to the eyes. That is the problem in domestic lighting, to get sufficient directed and sufficiently low diffused lighting so as to get the best vision; to get sufficient shadows to see by, but not too dark shadows to become tiresome. During the daytime we get directed light from the windows, and diffused light reflected upon the walls. To get the proper proportion between directed and diffused light, we have to employ shades, and we have to use walls of somewhat darker color. When you come to lighting in the evening, with a source of light like the incandescent lamp or gas lamp, concentrating light in all directions, then the diffused light compared with the concentrated or directed light will be a much better percentage than in the daytime for the same color of wall, partly due to the color of the light, which is yellow, and more reflected from the walls, largely, however, because with the daylight through the window the directed light is a much larger percentage of the total light than in the lamp, where only a small part is concentrated light. It is not comfortable to have this strong light, and we put shades on which absorb three-quarters of the light, but which give us a more comfortable illumination in the room. That means waste, however, and you pay twice for what light you get. The proper illuminating engineering is to secure the correct distribution curve of the source of light so as to give the desired amount of concentrated lighting on the dining room and reading table, and give only as much diffused lighting as is compatible with the amount of direct light used, to see by the shad-

ows. The problem of domestic lighting, from the illuminating engineering point, is to determine the illumination over the entire area, and also the character of illumination, whether directed or diffused; how large an amount of light should be concentrated, and how large an amount should be directed. Then also comes in as an important factor the question of colors and shades, as was discussed before.

DISCUSSION.

Mr. A. E. Forstall said that he realized that it was a piece of temerity to criticize Dr. Steinmetz, but that he was going to risk it and take exception to his reason for the non-luminosity of the Bunsen flame. He had studied the subject a great deal, and as a result had come to the conclusion that the Bunsen flame is non-luminous because the combustion of the carbon particles takes place so rapidly that they cannot give off light, so that there are no particles in the flame to be raised to incandescence. The chemical action in the Bunsen flame is naturally different from that in the ordinary luminous flame; this difference results in the hydrocarbons, which in the luminous flame are decomposed before they are consumed, setting free carbon particles which can be heated. In the Bunsen flame these hydrocarbon particles are entirely consumed and destroyed as hydrocarbon before the combustion is complete, by having the carbon turned into the carbon dioxide, before they can be decomposed and set free carbon particles. This seems to be the more nearly correct explanation of the non-luminosity of the Bunsen flame than the fact that the carbon particles are burned up so quickly that they cannot give light. If once formed it would be impossible for them to burn up so quickly that they would not give light.

The other point in the address which appealed to Mr. Forstall from his past experience with the value of different kinds of light for illumination purposes, was that in which the Doctor touched upon the fact that effective illumination depended not so much on the amount of light thrown on the object, as on the amount of light received and noted by the eye as coming from the object illuminated. In the Gas Association there was at one time a great discussion about the relative diffusive powers of light. Some of the engineers claimed that one kind of light diffused itself better than another kind of light, and therefore, though you might start with a much brighter light of the second kind, you would get very much less illumination than you would from a much less bright light of the first kind. What they really had in mind was that the light they said was less diffusive was so bright it tired the eye, and the eye could not see when it was turned away from it. That is the point which has to be kept in mind in all problems of illumination, and it is very often lost sight of.

Mr. Millar said that there were one or two points which Dr. Steinmetz spoke of, which he would like to comment on. One in particular was the question of the illuminating efficiency of green and red lights. He had undertaken a series of experiments in this connection. These are not complete, but preliminary experiments have yielded some rather interesting results. The method of measuring green and red lights indicated in the address, namely, the reading distance method, is going to be undertaken later. He has employed certain well-known forms of photometers and carried out some experiments with the mercury-vapor lamp. After all, the efficiencies of the mercury-vapor lamp, in so far as illuminating engineers are concerned with it, is illuminating efficiency. The photometer is an instrument to aid the eye in judging of illumination. We use the Lummer-Brodhun photometer, the Bunsen photometer and the Flicker photometer. We have made measurements on the mercury-vapor lamp in comparison with the incandescent electric lamps, at various distances, producing illumination varying from about 20 lux to 1 lux, distances from 10 to 50 feet. This has enabled us to investigate to some extent the effect which has been referred to, the Purkinje effect, which enables us to see with a low intensity of green illumination better than with a low intensity of red illumination. We have been very much interested to find that this effect has been, under the conditions stated, as great as 30 per cent., using the Lummer-Brodhun photometer that is to say, with the mercury-vapor lamp and carbon filament incandescent lamp of the same intensity of illumination, when measured at a distance of about 50 feet the mercury-vapor light is apparently 30 per cent. greater as judged by the Lummer-Brodhun photometer than that given by the incandescent lamp. With the Bunsen photometer this difference is reduced to about one-half, 15 per cent. With the Flicker photometer, the effect practically disappears. With the aid of the Flicker photometer, therefore, we will probably be able to judge of the illuminating efficiencies of the mercury-vapor lamp, and possibly lamps of other color values, with perhaps much greater accuracy than the reading distance method will permit.

Mr. Millar was much interested in the reference to improper lighting, as exemplified everywhere. He had been particularly

impressed recently with examples of this on the part of those interested in illuminating enterprises. If we look at the illumination in the offices of our gas and electric companies, we will find examples which certainly court criticism; and if we go into the offices of our lamp factories, we will also find the same state of affairs. It is like the case of the shoemaker's children, who are never properly shod. Yesterday he had visited the manager of one of the large lamp factories, and found him seated at a desk with a 50 c.-p. tungsten lamp, with a shade, about 15 inches in front of his nose. One spot on the table was highly illuminated, and the rest of the room was dark.

He thought the cause of illuminating engineering would be greatly advanced if we stopped scolding the public for the little attention they give to the subject and devote a little more time and attention to the matter of our own lighting installations.

Mr. W. H. Gardner, Jr., agreed with Mr. Millar's remarks about the quality of illumination in the offices of many gas and electric light companies. He thought Dr. Steinmetz had made a very interesting distinction between light and illumination. He did not offer this as an excuse for bad illumination, but suggested that gas and electric companies are advertising light as well as illumination in their offices. This matter has occurred to him in connection with commercial advertising; therein often it has seemed well to use light improperly from the illumination point of view, so as to catch the eye of the public.

Mr. Arthur A. Ernst, following up the idea of using light for purposes of catching the eye, said: "I think that applies principally to the spectacular form of lighting on buildings and signs, and not so much to stores. Illumination in my experience has always resulted in attracting attention, not because it is spectacular, but because the store shows up to better advantage and satisfies the eye. The spectacular form of illumination I think will have to be confined to the sign business and decorations of buildings."

"I was particularly interested in the part of Dr. Steinmetz's address referring to diffused and directed illumination. I had a recent experience in the matter of diffused lighting. When I took hold of the building in question, I had definite instructions as to the results to be produced. Among other things was perfectly diffused lighting, with sufficient intensity to enable everybody in the place to read without the addition of special lamps. I undertook the problem, placed my lights, made careful selection of the lamps as far as I was able, and made my calculations. I made an examination of the results after the installation was in use, and found that we had a perfectly diffused light. It proved highly satisfactory, and I took note as to the effect on the eyes. Aside from the diffusion that the average layman looks for, I looked for the shadows and how the eyes were affected by them. I noticed the fatigue that Dr. Steinmetz spoke of, and I searched for shadows from the chairs and tables, but could not find any. The quality of the light was quite satisfactory, and the reading intensity on the books was extremely so. There was a slight shadow on the book which I attributed to a difference in c.-p. in the chandelier, a point which I overlooked at the time I specified the c.-p. to be placed, but it was not enough to interfere with the reading.

Mr. Guy V. Williams, New York, thought that, in the matter of illumination, it is not always so much the efficiency we are after. Illumination has two effects: Psychological, which shows us the light is present, and also the physiological. The illumination we want depends on what we want it for. In a ballroom we want a bright, soft light, which will contribute to raising our spirits and enthusiasm. In art museums we want a strong light to bring out the beauty of the objects of art, if the object is perfect, but if it is not perfect, we want a softer light which will shield the blemish and make it appear as though it really were perfect. He had often noticed in some of the hotel lobbies where the illumination was brilliant, that it was probably some moments before he could see clearly. In the home, bright illumination is never desirable; in such a place we want a soft and very dim illumination.

Mr. V. R. Lansingh referred to Dr. Steinmetz's statement that in many cases shadows are decidedly objectionable, and mentioned the case of the draughting room. In desk lighting, shadows are also objectionable. He had never seen any quantitative values of shadows, as to what were objectionable and what were not objectionable. In many cases of lighting desks, owing to enormous sources of light, we cannot get away from shadows. If the shadows are too intense, they are very undesirable; on the other hand, slight shadow is not a matter of objection at all. He had carried out some experiments some years ago as to how intense a shadow could be without being objectionable. As near as he could find out, a shadow is unobjectionable if it does not rise above 20% of the rest of the illumination. If it rises to a greater value than that it is decidedly objectionable. He wished to emphasize the question of quantity as well as the intrinsic brilliancy of light, as referred to by Dr. Steinmetz. The intrinsic brilliancy of a 3.1 watt carbon lamp is about 500 c.-p., per sq. inch; while that of the Welsbach mantle is about 30 c.-p. per sq. in. Nevertheless, the bare Welsbach mantle is probably harder on

the eye than the ordinary carbon filament, because the quantity of light is so much greater. In the same way, the mercury-vapor lamp is very low in its intrinsic brilliancy, but the quantity of light is so great that to look at it, it is harder on the eyes than the ordinary bare incandescent lamp. With the Moore light, even, with a lower brilliancy still, if you look at it any length of time, that is also hard. In studying any lighting problem, we have got to study not only the brilliancy but also the quantity; the effect on the eye is due to both causes, not simply to the one or the other.

Mr. Paul McJunkin thought that the phenomenon referred to by Dr. Steinmetz of the selective reaction of the pupil of the eye, and the radiations of different wave-lengths, still further complicates the apparent difference in penetration of green and red light. At first thought he had hoped that this might be the solution of the apparent discrepancy; but a little consideration shows that it makes the difficulty even greater. He wished some one might suggest a possible explanation for the apparent difference in penetrating power. If any one present has made a bolograph of any of the highly efficient metal filaments, he thought the results would be interesting as touching on the possibility of the radiation from these filaments being selective, using that term in the broad sense of any departure from the radiations from a black body. The question had occurred to him as to whether the modified color values of the Bastian mercury lamp might be due to any difference in pressure from the ordinary mercury lamp; being explained by the phenomenon Dr. Steinmetz referred to, of the greater frequency reducing the vibrations to shorter wave-lengths, or whether it was due to a difference in temperature only.

Dr. Steinmetz, in closing the discussion, said: "I do not think I have to add much, except to state that I readily accept the correction regarding the Bunsen flame. What I should have said is, that the carbon disappears quicker in the free state. It cannot easily be seen, because when you take the transition from the luminous flame to the non-luminous flame, it is not a gradual, but a sudden change, progressing largely from one part of the flame to another one, but before you reach that point you notice an increase in intensity in the flame. In changing from a round burner to a flat burner the increased rate of combustion increases the efficiency, and then it disappears with the disappearance of the light-giving substances, just as the efficiency of the incandescent lamp first increases with increasing voltage, and then disappears with the destruction of the filament.

In regard to the relative intensity of green and yellow light, I was interested in the values given by Mr. Millar. I believe if he will follow this comparison to greater distances, down to the lower limits of physiological action, he will find still many times greater differences, because the green persists where the red fades out. I do not quite agree, however, with the conclusion that since the Flicker photometer shows no difference, that is the correct photometer. If we have three lamps, one giving 30 per cent., one 15, and one zero difference, the question is whether that showing 30 per cent. difference is nearer correct, or the one showing 15 per cent. difference is correct, or the Flicker photometer, giving no difference, is entirely incorrect, or the other way around. I personally have always suspected the Flicker photometer. The eye does show the difference; so that if we consider the light as a physiological effect, there must be some difference, because we notice, even with the naked eye, if we change the distances sufficiently, that the relative efficiency is changed. If the Flicker photometer does not show that, that confirms my suspicion that what the Flicker photometer measures is not the physiological effect of the two different lights, but the physiological effect of the average physical quantity. It compares the physical value and the intensity of radiation, but not the physiological action; in other words, where the physiological effect is different, we should expect that since the red is more persistent than the green—if you look at the red and green light and look away you see an after-image—if you look at the green light of the mercury lamp it is hard to get an after-image, as the image almost instantly disappears. Where you rapidly change from one color to another, you should expect that the red will give a longer lasting after-image than the green, and the after-image depends on the actual intensity; I think the Flicker photometer should at higher intensity show in favor of red, and the fact that it does not makes me more suspicious of it. I would be very much interested in hearing the results of the tests by reading distances, observing the reading of different sizes of print under these lights, according to the manner suggested by me.

Papers Read Before Technical Societies

TRANSFORMATION OF ELECTRIC POWER INTO LIGHT

By Charles Proteus Steinmetz.

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I. GENERAL.

Of all the achievements of modern science or engineering the production of light is the least creditable. In the transformation of electric power into mechanical power, as in the electric motor, or the transformation of mechanical power into electric power, as in the dynamo, efficiencies far higher than 90 per cent. have been reached. The transformation is practically complete. All further advance must be expected in the direction of increased reliability of operation, decreased size and cost, etc. Even in the steam-engine or steam-turbine, 60 per cent. or more of the available energy of the steam as it issues from the boiler is recovered as mechanical work.

In the production of light, the efficiency of the incandescent lamp is measured by a fraction of one per cent., and if we should succeed in increasing the efficiency of light production tenfold—get ten times as much light as we get now from the same power—the efficiency of production of light would still be ridiculously low; and even with a hundred times its present efficiency, it probably would compare unfavorably with efficiencies that are familiar to us in other electrical apparatus. While the incandescent lamp is more efficient than the gas-flame, or the kerosene lamp; that is, gives less heat with the same light, still its efficiency is extremely low. The main reason for this condition appears to be that in the incandescent lamp or the ordinary carbon arc-lamp the light is really a by-product. that is, the lamp converts electric energy into the heat, and only incidentally produces light.

II. LIGHTING BY INCANDESCENCE.

If energy is impressed upon a solid or a liquid, as by passing an electric current through a carbon filament, and no other work done, the body is heated. This energy must be given off again; it is given off partly by conduction, but largely by being radiated from the incandescent body. By increasing the power, the amount of radiation increases; and there are changes in the quality of the radiation too: first appear radiations of very great wave-length or very low frequency, then, with the increasing power, higher frequencies appear; that is, the wave-length of radiation becomes shorter. In other words, in addition to the long waves which appear in the beginning, shorter and shorter waves appear: not only the total amount of radiation increases, but also the variety of waves increases and, ultimately at a certain amount of heat given to the body or at a certain temperature, waves as short as 750 $\mu\ \mu$ appear. These are noticeable to the eye as dark-red light. Then still shorter waves appear gradually: orange, yellow, green, blue, lavender, violet. Beyond wave-lengths of 400 $\mu\ \mu$ the waves again become invisible, as so-called ultraviolet waves.

Of the infinite variety of waves radiated by a heated body—from the long waves given by liquid air to the shortest ultraviolet waves, many octaves of wave-length in all—somewhat less than one octave is visible to the eye. These wave-lengths are useful as light; the rest is wasted energy. A parallel would be found in the case of a musical instrument of six or eight or more octaves, producing less than one audible octave. To this fact is due the very low efficiency of light production by heat: of the total system of radiation only a very narrow range is useful, less than one octave.

Of these useful rays, the visible three-quarters of an octave, none appears until the temperature is fairly high. Below that, only the long waves appear. That means the average wave-length of radiation decreases with the temperature. Or, with increase of temperature, not only the existing waves become intense, but shorter and shorter waves appear, and the intensity maximum moves toward a shorter wave-length. With increase of temperature, the percentage of visible radiation thereby becomes greater and ultimately reaches a maximum, or the efficiency would be the highest when the maximum intensity lies just within the visible octave. Where this maximum may be is unknown, but it is beyond the temperature of the crater of the arcs, possibly somewhere between 4,000° and 5,000° cent. At that temperature the efficiency of the incandescent light is a maximum, and probably from one-quarter to one-half watt per candle-power. But even then the efficiency is not high, 5 to 10%, or thereabouts. It follows, however, that even if we could raise the incandescent body to the temperature of maximum efficiency, we would still get only about 5 to 10% of all the energy as light. The other 90% would be ultraviolet, chemical or actinic rays, X-rays, or long heat-

waves. There is thus an absolute limit to efficiency of lighting by incandescence.

The higher the temperature the greater the light efficiency of an incandescent body. Carbon is apparently the most refractory of all substances—its boiling point being somewhere near 3,500° cent., so an incandescent body, at the highest possible temperature and the incandescent crater of the carbon arc are the most efficient sources of light by incandescence. They are still somewhat below the temperature of the efficiency maximum.

Incandescent lighting is effected by the electric current, either by raising the temperature of the light-giving solid body, a lamp filament, by passing a current through it, or by passing the current from it into another body. In the latter case the temperature of the boiling point of the material is reached, and the crater of the carbon arc lamp is at the highest temperature which can be reached; gives it an incandescent light of maximum efficiency, probably not very far from half a watt per candle-power. But the large amount of energy, which is conducted away by air currents, etc., greatly reduces the actual efficiency of the carbon arc below this value.

When producing light by passing an electric current through the conductor, as in the incandescent lamp, no such efficiency can be reached. Here carbon is also chiefly used. The higher the temperature of the incandescent-lamp filament, the greater is the efficiency; but the limit of the temperature is not the boiling-point of carbon, 3,500° cent., but far below that; it is the temperature where evaporation of the filament becomes so rapid as to limit its life below economical requirements. This is probably not very far from 1,800° cent. Far below the boiling point, evaporation takes place: water evaporates at ordinary temperatures; even below the freezing point snow and ice evaporate very noticeably. An incandescent carbon filament evaporates, thereby decreasing in cross-section, and increasing in resistance; the current decreases, therefore the temperature decreases and with the temperature the efficiency decreases. As the condensed carbon vapor blackens the globe and obstructs the light, another decrease of light results from absorption. Thus efficiency has to be sacrificed in the incandescent lamp to get good life, and the specific consumption of electric power, instead of being one watt per candle-power (as in the case of the arc lamp) becomes as high as four watts per candle-power.

The arc, then, is the more efficient illuminant. But its efficiency is still low, and here there has been a similar result; to increase the life, the efficiency has been decreased by enclosing the carbon arc, in the present long-burning lamp. Increasing the efficiency of the arc by reducing the conduction of heat by a decrease of the diameter of the carbon has also been tried, with the same result—exchanging efficiency for life.

In the incandescent lamp, the problem of increasing the efficiency can be attacked in two ways. One way is to replace the carbon by a material which has a lower vapor-tension at high temperature. While carbon has the highest boiling point, it is not the boiling point which is of importance in a lamp filament, provided that this point is sufficiently high—it is the vapor-tension, far below this point.

For instance, the metals osmium, tantalum, wolfram (tungsten) have a lower melting point or boiling point than carbon, but they have at the same high temperature, a lower vapor-tension, due possibly to the much greater atomic weight and so much heaviness per molecule (atomic weight of carbon, 12; osmium, 191; tantalum, 183; wolfram, 184). These metals can be operated at a higher temperature than carbon, and as lamp filaments they give a much greater efficiency than the carbon filament.

The efficiency of the incandescent lamp can be improved by replacing the carbon filament with a material which has a lower vapor-tension, and a sufficiently high melting point. Tantalum, osmium, wolfram, or tungsten as materials for incandescent lamp filaments, promise to revolutionize the incandescent lamp, by holding out fair promise of an ultimate efficiency of about 2 watts per mean spherical candle-power for tantalum, 1.5 watts for osmium, and 1 watt per mean spherical candle-power for wolfram—compared with about four watts per mean spherical candle-power for the carbon-filament lamp. The objection to these metal filaments obviously is the low resistivity inherent to metals, which restricts their use to relatively larger units or at least makes difficult the production of low candle-power sizes.

Another way of improving the efficiency of the incandescent lamp is by improving the carbon. The vapor-tension depends not only on the chemical constitution, but also on the physical structure. Ice evaporates very much slower than a mass of loose snow. Furthermore, it is possible to produce different forms, possibly allotropic modifications of carbon, of different rates of self-destruction. The product of carbonization of fibre or cellulose can not be run at as high a temperature with the same length of life, as can carbon deposited from hydrocarbons, as benzol or benzine, by high temperature. Experiments with carbon at very high temperatures show probably greater variations in the character of carbon, than with any

other material. Possibly this is due to the tendency which the carbon atom has more than any other atom, of polymerization, and especially ring formation, which results in the formation of allotropic modifications of carbon, having the greater stability of such polymerized molecules. So at the boiling point of carbon, the carbon deposited from hydrocarbons converts, under the influence of atoms which can enter and leave the carbon chain, into an allotropic modification having pronounced metallic characteristics, as elasticity, a positive temperature coefficient of resistance, etc., and very great stability, so that as a lamp filament this form of carbon can be run up to a considerably higher efficiency, in the so-called "metalized filament."

III. SELECTIVE RADIATION OF SOLIDS.

Most incandescent bodies give the same, or approximately the same law of radiation, that of the so-called "black body"; that is, at the same temperature the intensity of radiation varies with the wave-length or frequency in the same manner, somewhat similar to that shown by Curve I, Fig. 1,* with a maximum at a certain wave-length. At higher temperature, Curve II[1], a similar intensity curve exists, with the maximum

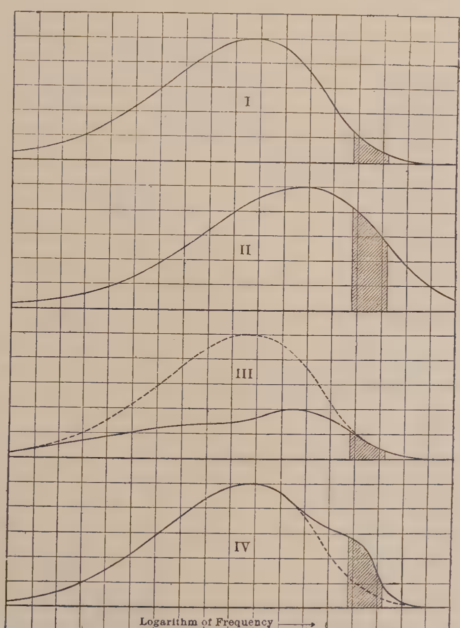


FIG. 1.

*These curves, drawn with the logarithm of the frequency of radiation as abscissas, are only illustrative, and not quantitative nor based on experiment, but merely illustrating the statements made above.

at shorter wave-length, or higher frequency, so that the intensity within the visible range, shown shaded in Fig. 1, is a higher percentage of the total radiation; that is, the efficiency of light production is higher.

If, however, a body could be found which at the temperature corresponding to Curve I, gives an abnormally low radiation outside of the visible range, as illustrated by Curve III, or which with normal radiation in the invisible range gives an abnormally high radiation in the visible range, as illustrated by Curve IV, then in either case the visible radiation would be a greater percentage of the total radiation than corresponds to the temperature; that is, the efficiency of light production would be higher than that of a black body at the same temperature. Theoretically such a body with selective radiation might give an efficiency higher than the absolute maximum of light efficiency of black-body radiation.

Either of the two cases; abnormally high radiation in the visible, and abnormally low radiation in the invisible range, may give the same shape of intensity curve, the only difference being that in the first case the total radiation per unit surface is higher, in the last case lower than that of a black body at the same temperature. That is, with the same amount of light radiation and the same efficiency, in the last case the radiating surface is greater than in the first case, and this may give a criterion to decide between the two alternatives.

With such selective radiation, there is a distribution of intensity throughout the visible range and so the color of the light may differ from that of an incandescent body. With abnormally high radiation in the visible range, the increase of intensity is probably greatest in the middle of the visible spectrum; with abnormally low radiation in the invisible, the decrease of intensity is least in the center of the visible spectrum. In either case the tendency is towards preponderance of the wave-lengths in the middle of the visible spectrum; that is, the greenish-yellow, as characteristic of such selective radiation, and apparent in the Welsbach mantle. Typical of such selective radiation is the lime cylinder of the calcium light, and possibly the flame of burning magnesium.

With gas as illuminant, a very great increase of efficiency has resulted from the use of selective radiation; as found in the Welsbach mantle.

In electric lighting, the Nernst lamp probably represents in the first attempt, on a large scale, of improving the efficiency of light production by selective radiation. It has not been as successful as in gas lighting, since the efficiency of the Nernst

lamp does not differ much from that of the carbon incandescent lamp, while the efficiency of the Welsbach mantle is many times higher than that of the ordinary gas flame. The reason probably is that with a very inefficient illuminant, as the gas flame, the additional light given by selective radiation may increase the total light several fold, while the same amount of additional selective radiation with a relatively far more efficient illuminant, as the incandescent lamp, is a far lower percentage of the total visible radiation. Or, to illustrate, the additional shaded area between the dotted and the drawn line in Curve IV, Fig. 1, increases the efficiency threefold, while the same additional area, added to the shaded area of Curve II, would not materially increase the efficiency. That is, the increase of efficiency by selective radiation of an incandescent body becomes less with a more efficient illuminant, and selective radiation may greatly increase the efficiency of inefficient illuminants, but not so much that of efficient illuminants, so that the hope of very greatly increasing the efficiency of light production by selective radiation of solids does not appear very strong. However, some of the recent very efficient incandescent-lamp filaments, as tungsten and osmium, may owe their high efficiency partly to selective radiation; that is, they give light not only by incandescence, but also by luminescence.

IV. ELECTROLUMINESCENCE OF VAPORS AND GASES.

The problem of efficient light production consists of producing radiations; that is, vibrations of the molecules or atoms of the light-giving body, of frequencies within a limited narrow range, that of a visible radiation, and as few vibrations as possible outside of this range. When heating a solid body, the energy put into it as heat sets the molecules or atoms in motion, in vibration. Where they are close together, as in a solid or liquid, they cannot vibrate freely; each cannot have a period of its own. Just as all the different grains in a sand heap can not vibrate simultaneously as do the molecules of a tuning fork, and the vibration is irregular. All you can get is a mixture of all kinds of vibrations, not a tune, but a noise. To get a tune requires a body which can vibrate freely without restraint; that means a gas; as the gas molecules are free, they can execute free vibration. A vibration of a definite pitch, definite frequency, that is definite color of light can be produced only in a gas or vapor. But when heating a gas or vapor, the energy put into it appears not as vibration of the molecules, except perhaps indirectly at extremely high temperature, but as rectilinear motion or pressure. The molecules move faster in their rectilinear paths, and so strike the boundary at higher velocity; the pressure of the gas rises by increasing molecular velocity, that is, increasing temperature, but the vibration of the light radiation does not appear. So heat, while making a solid or liquid incandescent, does not make a gas incandescent or luminous but merely increases its pressure.

There are methods, however, of setting the gas molecules in vibration. By chemical reaction or electric stress, gases become luminescent; that is, the molecules of the gas are set in vibration. For instance, if the gas is used as a conductor of electric current, then the molecules of the gas are set in vibration, and we find a definite period of vibration, or a number of periods or frequencies, in which the gas molecules or atoms can vibrate; that is, gases give line spectra. So in a mercury arc, the molecules vibrate not as those of a solid body, but only with a small number of wave-lengths. Many of these are within the visible range, within the fraction of an octave which is seen by the eye: one is of a greenish-yellow; another wave is green; another is dark-green; another is blue. Two vibrations appear as violet, and numerous vibrations excited by the mercury arc are, in the ultraviolet, very short.

Here results a definite rate of vibration, practically independent of the temperature. The mercury vapor vibrates at that frequency which gives that particular yellow light, and that particular green light, etc., whether the temperature is high or low, and the wave-length does not change as it does with the radiation of a solid incandescent body; it is fixed by the nature of the molecule, so that the temperature has no direct effect. It has an indirect effect in so far as at higher temperature, periods of vibrations may become more prominent, while small, or almost non-existing, at low temperatures. For instance, in mercury vapor the lowest frequency is that giving the greenish-yellow line, but no appreciable amount of vibration is so slow as to give red light at ordinary temperature. When you raise the temperature very high (but still below the temperature of the incandescent-lamp filament) then the mercury molecule begins to execute a slow vibration, which gives an intense red light, and red lines appear in the mercury arc; with increasing temperature it gradually changes its color from green to white to red. Here we have a particularly interesting illustration that for luminescent vapors or gases the law of the black-body radiation does not apply. In a solid black body, with increasing temperature, the mean wave-length decreases, shorter waves appear, and the light changes from the red over yellow toward white. Now it happens that with mercury vapor at the higher tempera-

ture, a slower vibration, or longer wave, of red light, increases in intensity faster than the short vibrations, and the light changes from green to white and ultimately to reddish-pink at high temperature. It is a mere incident, but is shows that temperature has no effect directly, only indirectly, in that particular rates of vibration may appear with change of temperature, may become more or less prominent, depending on the material which luminesces.

As a rule, then, it can be said that such an arc or a luminescent gas or vapor is more efficient as a producer of light, the lower the temperature. This is just the reverse of the solid incandescent body. In a solid body the higher the temperature the larger a percentage of radiation is within the visible range, and the higher the efficiency. In a gas or vapor, a certain definite vibration is impressed directly by the electric energy or the chemical energy which sets up the oscillation; the heat which is produced is incidental, is a by-product and therefore a waste. The lower the temperature the less waste of energy takes place as heat, and the more efficient is the luminescent gas. With a luminescent gas the heat is a by-product which we want to decrease just as in an electric motor or generator; that is, the lower the temperature the better. This is one reason why the mercury arc is extremely efficient; it has the lowest temperature.

Theoretically, there is no limit to the efficiency of a luminescent vapor. A vapor may be imagined which vibrates only with one particular wave length, say a yellow line. That means all the energy put into it must be radiated at that particular wavelength, as yellow light, and therefore the conversion of electric energy into light would be 100 per cent., not counting the energy lost by heat convection or conduction. The latter can be made very small by enclosure in a vacuum. Complete conversion of electric power into light would so result, if all the spectrum lines were within the visible range. That is never the case. There is no definite law giving the percentage of energy which appears as radiation in the visible spectrum, and which appears outside of the visible range as ultrared and ultraviolet lines; but the position of the lines in the spectrum is an individual characteristic of the gas or vapor. The problem of efficient light production is to find a material having most lines in the visible range of the spectrum.

With mercury vapor which is set in vibration by the current, a very high percentage of the total energy is radiated in the visible range. With carbon vapor, the percentage of energy radiated in the visible range is extremely small. The carbon arc is extremely low in efficiency, practically non-luminous. Silicon also gives a practically non-luminous arc. Others, like calcium, titanium, etc., give a very high percentage of light within the visible range, and so a high efficiency of light production.

The color of light produced by incandesence varies from reddish-yellow at low temperature to yellow, and approaches yellowish-white at higher temperature. Selective radiation of solids tends to superpose hereon a preponderance of greenish-yellow rays, without, however, greatly changing the color. With electroluminescence of vapors and gases, however, the color of the light depends on which of the spectrum lines happen to be most prominent.

Electroluminescence makes it possible to produce light of any color. This, however, greatly complicates the question of efficiency. As efficiency can no longer be considered the ratio of the power radiated within the visible range to the total power input, since the different parts of the visible spectrum have entirely different energy-equivalents: one candle-power of red light, or of violet light, represents many times more power which issues as radiation, than one candle-power of green or of yellow light. That is, the light-equivalent of power is a function of the wave-length. It is obviously zero in the ultrared; it is very low in the dark-red; and gradually rises to a maximum in the yellow and green, and then decreases again, becoming very low in the violet and zero in the ultraviolet. One candle-power per watt as red light or as violet light may therefore represent a fairly high efficiency, while 10 candle-power per watt, with green or yellow light, would be a far lower efficiency. That is, the energy radiated in a beam of one candle-power red light probably is greater than the energy of a beam of 10 candle-power of green light.

This feature explains the impossibility of determining efficiencies of light by the measurement of physical quantities. Light is the physiological conception of some wave-lengths of radiation, but no physical quantity.

Where high economy of light production is the only, or the foremost consideration, spectra in which green or yellow preponderates are therefore selected; for instance as mercury, bluish-green in the mercury arc lamp—or calcium—yellow, in the flame carbon lamp. These two illuminants give high efficiency, but they give it by sacrificing the inefficient colors at the end of the visible range. But, unfortunately, the sun, as an incandescent body, gives the light of solids or liquids, and therefore gives all the radiations, with the red end of the spectrum specially prominent and, since we call the sun white, the light from the mercury arc appears green, that of the flame

carbon arc yellow; not the yellow of the incandescent lamp, but a pronounced monochromatic hue.

The mercury arc and the flame carbon arc are useful for cheap lighting, regardless of color. They also find an application for special effects due to their color. So the mercury arc is eminently suited for outdoor lighting in suburban districts where its effect on foliage and snow makes it superior to illuminants containing red rays and so intensifying the appearance of incipient death in the vegetation, and where the intrinsic brilliancy of illumination can be kept sufficiently low as not to show the objectionable effect of monochromatic light. The flame carbon arc finds its field in advertising, where its intense glare makes it especially suitable.

For general illumination, however, at least in this country, people have become educated to require as close an approach to daylight as possible; that is, to require white light. The problem, then, is to find a vapor which gives spectrum lines over the whole visible range, distributed approximately in the same manner as the intensity in the solar spectrum, and giving as few lines as possible outside of the visible spectrum.

A spectrum giving spectrum lines uniformly distributed in their intensity over the whole visible range, should not give white, but a pronounced green light, due to the higher physiological effect of the radiations in the middle of the spectrum. By the law of probability, amongst the spectra of the chemical elements, the predominant intensity of radiation should be found just as often in one wave-length as in any other. Physiologically, therefore, green should predominate in the colors of metal spectra. To a certain extent this is true. Red metal spectra are rare, green most prominent. Bluish metal spectra, however, are much more frequent than should be expected by probability, and it therefore seems that in molecular vibrations of vapors, shorter wave-lengths or higher frequencies predominate. This may be due to the size and mass of the molecules being such as to have a mean frequency of oscillation higher than the average frequency of visible light.

V. VACUUM-TUBE ILLUMINATION.

Conduction through vapors can be of two distinctly different characters: spark or Geissler tube conduction, and arc conduction. Vapors or gases can be divided into two classes: conducting vapors, and non-conducting vapors. The conducting vapors are all of very high resistance. Hydrogen or air may be called a conducting gas, because a current can be passed through it, especially at a moderately high vacuum, as in the Geissler tube, which is nothing more than a tube containing the gas used as a conductor, at a few millimetres pressure. At this pressure, air becomes a fairly good conductor, but the resistance is very high compared with the resistance of conducting solids or liquid. The passage of current through the conducting gas of the Geissler tube produces light, by some form of luminescence.

The mechanism of this light production does not seem to be known, but the light seems to be somewhat of the character of a by-product. The Geissler tube is extremely efficient when operated with an alternating current of very high frequency. With decrease of frequency, its efficiency decreases and heat is produced; that is, the frequency of radiation from the Geissler tube seems to vary with the frequency of the impressed alternating electromotive force, and have its intensity maximum near the visible range only at very high frequency currents. The production of light in the Geissler tube therefore seems to be connected in some way with the change of electric stress. It is not dependent upon it, because even with a steady current the Geissler tube gives light, but its efficiency of light production vastly increases, and the energy is converted more into light and less into heat, with increasing frequency. Herein seems to lie the great difficulty in this method of producing light by using conducting gases at low pressure.

Considerable work has been done in this direction by able investigators, and with some success. The Geissler tube gives a very nice light; and by using a suitable gas it can be made to give any color, only the intrinsic brilliancy is very low. Very large tube surfaces must therefore be used for illumination, of a magnitude probably a hundred times as large as with the mercury arc, which latter is already recognized as a luminous source of low intrinsic brilliancy. In the last years, even with a frequency of 60 cycles, good efficiencies seem to have been reached. I do not believe it possible, however, to approach the magnitude of efficiency as given by the mercury, calcium, of titanium spectrum.

VI. THE ARC.

In the Geissler tube the current is carried bv the gas or vapor which fills the space between the electrodes. The conduction is disruptive in character, or a spark discharge; that is, a minimum voltage is required. Below this voltage, no conduction takes place; above it the current passes, with the appearance of luminescence; and if the voltage falls below the minimum value required to start conduction, the current again ceases. The material of the electrodes has no direct effect, but the

spectrum is that of the gas between the electrodes. The character of the current also seems to have no direct effect; alternating current passes at about the same voltage as direct current.

An entirely different set of phenomena is met in arc conduction. The electric arc makes its own conductor. That is, the current is carried across the gap between the electrodes by a vapor-bridge, produced by the current from the material of the negative electrode and maintained by the current as a high-velocity vapor-stream issuing from the negative towards the positive, and more or less surrounding the positive terminal. The spectrum of the arc, therefore, is that of the negative terminal, but independent of the gas or vapor filling the space around it, or of the material of the positive terminal, except indirectly by the effect of heat, etc.

The continuous production of the vapor-stream requires power in raising the negative material to the boiling point, evaporating it, and producing its rectilinear velocity. This power must be supplied by the electric circuit, as a potential drop at the arc terminals, independent of the length of the arc, and of the current—if the volume of the vapor-stream is assumed as proportional to the current, which seems to be the case. This potential drop, e_0, may be called the counter electromotive force of the arc.

The temperature of the arc-stream, at constant pressure in the surrounding space, must be constant, that of the boiling point of the material of the negative terminal. The power radiated per unit surface may therefore be also assumed as constant, and the total power radiated, and therefore the power consumed in the arc stream, as proportional to its surface; that is, to the product of length by diameter. Since the section of the arc-stream can be assumed as proportional to the current, it follows that the voltage consumed by the arc-stream is inversely proportioned to the square root of the current, and approximately proportional to the arc-length, or, when allowing for the abstraction of energy from the arc-stream by the terminals, proportional to the arc-length plus a small constant quantity.

This gives the theoretical volt-ampere equation of the arc:

$$e = e_0 + \frac{a(1+c)}{\sqrt{i}}$$

Giving the arc length 1 in inches, numerical values of this equation are:

Carbon Arc:

$$e_0 = 36 + \frac{130\,(1+0.33)}{\sqrt{i}}$$

Magnetite Arc:

$$e_0 = 30 + \frac{123\,(1+0.05)}{\sqrt{i}}$$

With zinc or cadmium the counter electromotive force of the arc is:

$e_0 = 16$ volts; with mercury, $e_0 = 13$ volts.

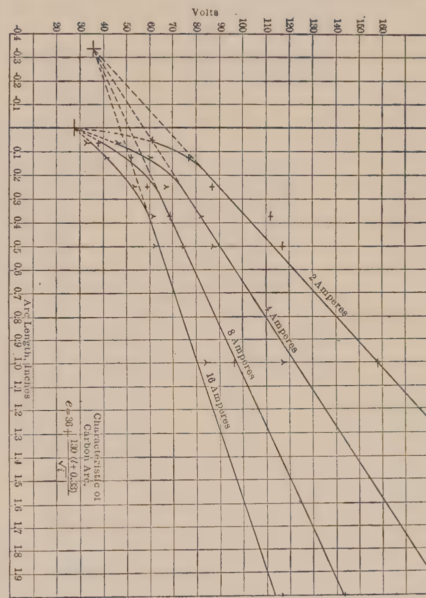


FIG. 2.

In Figs. 2 and 3 are given characteristic curves for these arcs, for 2, 4, 8, 16 amperes, drawn from above equations with the values observed by test marked by crosses. As seen, the agreement of the calculated curves with test is as close as can be expected from an approximate formula, with the exception of the carbon arc, in which the agreement is least close. In the carbon arc, for short arc-lengths the

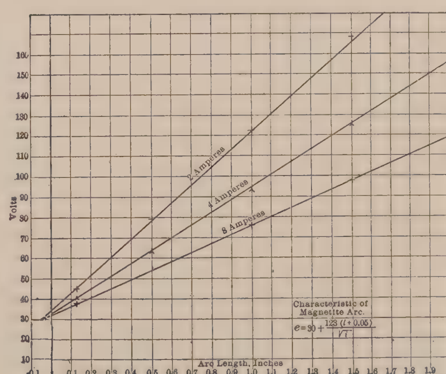


FIG. 3.

curves leave the straight lines and slope down toward a value of about 28 volts at zero arc-length. Separating two carbon electrodes from each other and observing the voltage at the moment when the carbons leave immediate contact with each other and the voltage suddenly rises, or observing the voltage immediately before the carbons, when shortening the arc, come in contact and the voltage suddenly drops, also gives values around 28 volts. This in connection with the high value of the constant $c = 0.33''$, looks as if in the carbon arc the seat of the counter electromotive force e_0 is not the immediate surface of the terminals, but a part of e_0, about 8 volts, residing in the space surrounding the electrodes. This phenomenon may, however, be explained also by energy transfer from the hot crater of the positive terminal to the negative terminal at a short arc-length.

For very low currents, where the arc-stream gets very thin and unsteady, and abnormally high energy losses may be expected, the above equations give small values; that is, the observed arc-voltage is higher than the calculated, especially with long arcs. So for the magnetic arc of one ampere, we find:

At arc-length	1-8 in.	1-2 in.	1 in.
Observed voltage	58	108	184
Calculated voltage	51.5	97.5	159

These equations obviously apply to the arc at constant pressure, as an arc in air, in which the arc-section varies with the current. For an arc of constant section, in which therefore the pressure and the temperature varies with the current, as the mercury arc in a vacuum, by similar considerations an approximate volt-ampere characteristic is found. This is for the mercury arc:

$$e = 13 + \frac{1}{1.68\,d - 0.066\,i - \frac{1 \cdot 3\,d^2}{1}}$$

with non-volatile positive terminal, and:

$$e = 13 + \frac{1}{1.68\,d - 0.114\,i - \frac{1 \cdot 3\,d^2}{i}}$$

with mercury anode.*

where: 1 = arc-length,

d = arc-diameter, in inches.

From the character of arc-conduction—that the current makes its own conductor—it follows that the arc must be started; that is, the vapor-bridge which carries the current must first be produced by the expenditure of energy before the current can flow. This can be done in many ways: by bringing the terminals in contact with each other and so starting the current, and then by withdrawing the terminals from each other to form the arc-stream by the current; or by jumping an electrostatic spark across the gap and so starting conduction.

It also follows that the arc is a direct-current phenomenon, and in general can not exist with an alternating current. With an alternating electromotive force at the end of the half-wave, the current dies out and therefore also the vapor-stream; and the next half-wave, to pass in opposite direction, requires a vapor-stream moving in the opposite direction. This does not exist, and the current does not pass; but the arc dies out at the end of the half-wave, except if the supply voltage is sufficiently high to jump a spark across the terminals at every half-wave, through the residual vapor left by the preceding half-wave. An alternating arc, therefore, must be at every half wave in the condition for starting by a spark. Stroboscopic photographs with metal arcs show this phenomenon: a sharply defined static spark at every half wave, gradually spreading out to the more diffuse arc-flame and then dying out at the end of the half-wave, to start again by a spark at the next half-wave.

The voltage required to maintain the vapor-stream; that is, the voltage consumed by a direct-current arc, as discussed above, increases with increase of the arc-temperature; that is, increase of the boiling point of the terminal material. It is lowest for the mercury arc, highest for the carbon arc. For a ½-in. arc it is shown approximately by Curve I in Fig. 4, with the temperature as abscissas. The voltage required to jump a spark across the gap between terminals, shown roughly by Curve II in Fig. 4,* decreases with increasing temperature, as is well known, and intersects Curve I at some temperature, A, probably somewhere between 2,500° and 3,000° cent. Above this temperature, the spark-voltage is below the arc-voltage, and a voltage sufficiently high to maintain an arc is therefore sufficiently high to start it again at each half-wave of alternating electromotive force. That is, materials as arc terminals, which have a boiling point above the temperature of intersection A of Fig. 4, maintain a steady alternating-current arc at about the same voltage as a direct-current arc; while materials with a lower boiling

*The effect of the anode material on the arc characteristic is indirect. In the case of the mercury anode the heat produced at the anode causes evaporation, and increases the vapor pressure above that existing with a graphite or iron anode.

*This curve is only estimated, and so can make no claim to numerical accuracy. Curves I and II, the arc- and the spark-curve, are shown once more in ⅓ scale (left-side ordinates) in dotted lines, and the lower part of II once more, in 1-25 scale, as II" in, Fig. 4.

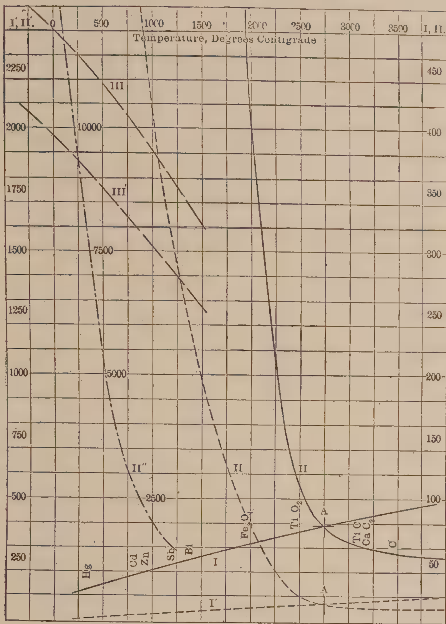


FIG 4.

point than A require a higher voltage, usually very many times higher, to maintain an alternating, than a direct-current arc. It must be considered, however, that the temperature of the boiling point, while being the foremost factor, is not the only factor in determining the position of a material on Curves I and II, Fig. 4. Individual characteristics somewhat modify the position.

Where therefore spark-gap terminals are desired not to maintain an alternating arc, as for lightning-arrester cylinders, they are found on the lower range of the curve: mercury, cadmium, zinc, antimony, bismuth, —the so-called "non-arcing metals." Where electrodes for alternating-current arc lighting are required, they are found at the upper end, above A. In this range belong carbon and most carbides, as those of calcium and titanium. Even carbon shows the phenomenon of restarting at every half-wave, by a high peak at the beginning of the electromotive force wave, as shown first by Tobey and Walbridge, in a paper on alternating-current arc waves.* With increasing approach to A, this peak at the beginning of the electromotive force increases in height, and the power-factor of the circuit tends to decrease, by wave-shape distortion. Immediately below the intersection point A are found very refractory metals as tungsten, and metaloxides, as those of titanium, etc.

*Transactions A. I. E. E., 1890, Vol. 7, p. 367.

The range of voltage between Curves I and II in Fig. 4 is the range in which rectification takes place. That is, by maintaining the vapor-stream issuing continuously from one terminal, by an outside source, or by the overlap of several arcs, the alternating electromotive force can pass a current in one direction only, and so is rectified. In this range, the arc-stream is an unidirectional conductor, of very low resistance in one direction, of practically infinite resistance in the opposite direction.

The voltage range of rectification, then, is highest at the lower end of the curve, and decreases gradually to zero at the point A. With the first members of the group, the upper limit of the rectification range is somewhat cut down by the disruptive strength of the air surrounding the arc-stream, being lower than that of the arc-stream, and so passing a static spark outside of the arc-stream, or, with a vacuum-tube arc, by a Geissler tube discharge through the residual gas. In the latter case the maximum voltage which can be rectified depends upon, and measures the perfection of evacuation. Such Geissler tube discharge curves are sketched roughly, in dotted lines, as III, III' in Fig. 4.

While vapors like mercury, zinc, etc., are very good conductors when in motion under the influence of the current, of a conductivity comparable with that of electrolytes; when not under the influence of the current they are almost perfect insulators, and so can be distinguished from the so-called "conducting gases," as hydrogen, air, etc., as "non-conducting vapors." Low-temperature metal vapors thus are non-conductors.

VII. THE ARC AS AN ILLUMINANT.

The spectrum of the arc is that of the negative material; its temperature that of the boiling point of the negative. There are, however, some apparent exceptions. For instance, the arc-stream can be superheated by using a high-frequency oscillating current of sufficiently high voltage to maintain an alternating arc, and a frequency so high that a sufficient vapor-stream can not be formed during the half-wave. In this case, groups of spectrum lines frequently become prominent, which are insignificant with saturated vapor: the mercury arc becomes bright-red in color; the iron arc loses most of its brilliancy, but gives a great quantity of intense ultraviolet rays, etc. Likewise, the spectrum of the positive, or a constituent of the positive terminal, can be made to appear in the arc.

The tip of the positive is heated to the temperature of the vapor-stream, in the carbon arc the temperature of boiling carbon. If the positive terminal consists of,

or contains some material which boils below the temperature of the vapor-stream, then it will evaporate out of the positive, and may thus enter the arc-stream. For instance, in a carbon arc, or arc with carbon as negative, if a carbon is used as positive, impregnated with calcium fluoride or borate, which has a relatively low boiling point, then the calcium vapor enters the arc-stream and is thereby heated to the temperature of the carbon arc. It becomes luminescent, whether directly by heat, or indirectly by chemical dissociation, or otherwise, need not be considered here. So the efficiency of a carbon arc can be increased by feeding into the arc-flame the vapor of some material which gives a brilliant spectrum—as calcium, which gives a yellow light of very great brilliancy. It is fed into the arc by the positive terminal, because this is the hottest, and the efficiency depends entirely on the temperature of the positive. If the positive is very large, so as to keep cool and consumes slowly, the efficiency decreases, because it is produced only indirectly by material being evaporated from the positive and then as vapor entering the arc-stream. Therefore a high temperature and rapid consumption of the positive are necessary.

It is entirely different with the true luminous arc, which carries the light-giving material into the arc-flame by the electric current, as the vapor-blast, which carries the current. The carbon as negative material is objectionable, since it gives the non-luminous carbon arc. Iron appears to be a very suitable material, since it gives a spectrum extending over the whole visible range. It produces practically a white light. The positive can then be maintained cold without affecting the brilliancy or efficiency of the arc. The negative can also be cooled without appreciable effect on the efficiency, since the current still produces the vapor-blast from it, and so the light. If cooled too much the voltage in the arc may rise a little, because it requires more energy to produce the iron vapor from the cool negative than from the hot negative, but still the efficiency is not much affected.

There are, then, two distinct ways of producing luminescence of the arc: first, directly by using some material as negative which gives a luminous spectrum; that is, a spectrum with many lines in the visible range, preferably covering the whole range, to get white light; secondly, indirectly by using some material to carry the current which gives a very high temperature to the arc-stream—which means practically carbon—and making the arc-stream luminous by feeding some light-giving substance into the arc from the positivve terminal. In the former case the arc has the characteristic of the iron arc or titanium arc, whatever material is used; in the latter case, it has the characteristic of the carbon arc.

Since the carbon arc is the steadiest arc, the most work has been done in the latter direction. The former method, of feeding the luminescent material by the current from the negative material, has the advantage, however, that the efficiency does not depend on the temperature of the electrodes: the rate of consumption of the negative electrode can thus be greatly decreased by maintaining it at low temperature; while the positive electrode, which takes no part in the arc conduction, can be made entirely non-consuming. This method seems to be a more direct conversion of electric power into light.

These two forms of an arc have come into prominence recently the flame carbon arc and the metal compound arc; that is, an arc in which carbon is not used, but some other material which gives a luminous spectrum, as iron or titanium. In the former case the characteristics are those of the carbon arc. All the materials which can be used to increase the efficiency of the carbon arc—calcium compounds are used almost exclusively—deposit as solids after passing through the arc-flame, and therefore ventilation must be provided to carry off the smoke; that is, the arc must be a so-called "open" or "burning" arc. The life of the electrodes is about 10 hours. Flame carbon arcs therefore have short-life electrodes, though their efficiency is high. Again, efficiency has to be balanced against life, or decreased cost of power against increased cost of electrodes and attendance. Here in the States the short-burning arcs for street lighting have practically disappeared. Indoors the excessive brilliancy and the smoke are objectionable, so that the flame carbon arc does not offer much prospect for general illumination.

More prospect of success appears to exist in the true luminous arc, an arc using as negative a material giving an efficient and brilliant spectrum. Such material should give lines uniformly distributed not only in the green or yellow, but over the whole visible range, and the material should not be attacked in air, even at high temperature. The arc must be an open arc, since the material deposits are solid, and to get electrodes with long life, a material is required which is stable at high temperature in the air.

There are very many metals which give luminous spectra, but those which give white are substantially the metals of the iron group only—iron, titanium, wolfram, etc.

Long-burning quality requires a material which is not affected, or only little affected by the air. This, in general, excludes the metals, but requires a stable oxide or other fairly stable compound, as some carbides

are. It should also be a conductor, since as arc electrode it has to carry the current. In the intermediate oxide of iron magnetite ($Fe_3 O_4$), material is found which is a good conductor, is stable at high temperatures as well as at low temperatures and gives a white spectrum. In such electroluminescent arc, any stable material is suitable as a positive terminal. Copper is generally used because it is cheap, is stable at fairly high temperature, is a very good conductor of heat, and when heated by the arc carries the heat away with sufficient rapidity not to melt or oxidize appreciably. In all these arcs the vapor stream from the negative is a necessity. In the mercury arc it is easiest of observation, because the arc is enclosed in a glass tube.

The amount of vapor produced by the current from the negative is usually many times greater than necessary to carry the current, and most of it can be condensed without any appreciable change in the arc-stream. So also magnetite consumes at a much greater rate than is necessary, of an order of ¼ gram per ampere-hour. This rate of evaporation is greatly reduced by the addition of small quantities of a material which is chemically not much different from magnetite, but is much more refractory; so that at the temperature where the magnetite melts this material is still solid and forms a kind of sponge in which the melted magnetite is held and its consumption greatly retarded.

Magnetite, however, while a good conductor of the arc-stream, is not very efficient as a producer of light, and added thereto are other materials which give a very high efficiency, as titanium compounds.

In the magnetite arc—as used at present, that is, in which the magnetite electrode contains titanium oxide, etc.—magnetite is essentially the carrier of the arc conduction, just as carbon in the yellow-flame arc; titanium with its highly efficient white spectrum takes in the magnetite arc the same place as calcium in the flame arc, as light-giving substance, but titanium is carried into the arc stream by the current from the negative, while calcium in the flame arc enters by evaporation from the positive.

The elimination of carbon in the magnetite arc excludes combustion, and this increases the life of electrodes to about twenty times that of carbon electrodes under the same conditions; but just as with the carbon arc, the efficiency of the magnetite arc can be varied over a wide range, with a corresponding variation of life in opposite direction. That is, by sacrificing some efficiency the life can be greatly increased, or the efficiency can be increased by somewhat reducing the life, by increasing the percentage of light-giving material: usually titanium oxide in the magnetite arc, calcium fluoride or borate in the flame carbon arc. In either case, a very high percentage of the light-giving material tends to the formation of a non-conducting slag at the electrode surface, and if the highest possible efficiencies are desired—¼ watt per candle-power, and better—the effect of the non-conducting, or poorly-conducting electrode surface has to be eliminated, by starting the arc from the side of the electrode, or some other method.

Magnetite, titanium oxide, and most metals or their compounds are on curve Fig. 4 below the intersection point *A*; that is, do not maintain a steady alternating arc. For alternating arcs, therefore, one of the materials is required which is above point *A* in Fig. 4. In this range, there are carbon, carbides, and similar compounds.

Thus the titanium arc with alternating current can not use magnetite as carrier, and titanium oxide as light-giving material; but titanium carbide is used as arc conductor. It obviously is not so incombustible as the oxide, but still so much more stable than carbon as to be well within the range of long-burning arcs.

To conclude, then, in the luminous arc we seem to have the first instance of a commercial application of a direct conversion of electric power into light, without heat as intermediary form of energy. It is not limited to very low values of efficiency. But so far as it seems that only the green mercury spectrum, the yellow calcium spectrum, and the white titanium spectrum offer an efficiency so vastly superior to that of incandescent solids, that as regards the efficiency of light production no possible improvement in incandescent lighting could hope to approach it. Typical of these three most efficient spectra are the mercury-arc lamp, of practically infinite life and bluish-green color of light; the yellow flame carbon arc of the short life of the open arc-lamp of old; and the white titanium carbide or magnetite arc, of a life equal to or greater than that of the enclosed carbon arc.

NEW TYPES OF INCANDESCENT LAMPS

By Clayton H. Sharp.

Presented to the Am. Inst. of Elec. Engrs. Nov. 23, 1906. From the *Proceedings*.

For a number of years the standard of electric lighting has been set by the carbon-filament lamp consuming initially 3.1-watts per candle-power. Progress there has been; but it has been chiefly in the way of minor improvements in the process of manufacture, rating of lamps, and in the way of a

more general adoption by electric companies of the 3.1 watts-per-candle lamp. This watt-per-candle consumption has been recognized as the minimum practicable under good operating conditions. Any radical or considerable improvement in the lamp itself has seemed improbable of attainment. The degree of improvement which has been made in the carbon filament lamp has been indicated by data given by Mr. J. T. Marshall in a paper before the Franklin Institute*. The continuous increase in the effective life of incandescent lamps burned at 3.1-watts per candle between the years 1888 and 1904, as given in Marshall's paper, as shown in the curve, Fig. 1. The

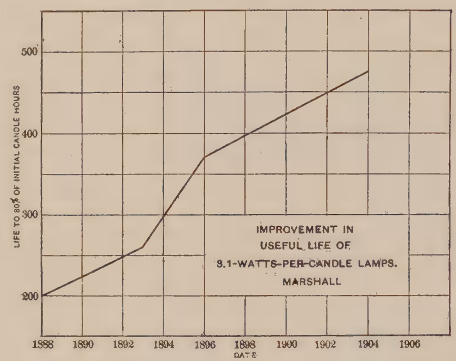


FIG. 1.

effective life at the present time is seen to be substantially two and one-half times as great as the life in 1888. The advent of the osmium lamp cannot be said to have altered the state of affairs materially. In spite of its very high efficiency and long life, this lamp seems precluded from exercising any revolutionary influence on lighting practice, on account of its low voltage and most of all by the limitations of the visible supply of the material of which the filament is composed.

Within the last two years the situation has altered materially. A marked improvement in the process of manufacture of carbon-filament lamps which has been announced and described by Mr. John W. Howell before this Institute† has resulted in the commercial production of lamps which operate on a 2.5-watts-per-candle basis instead of a 3.1-watts-per-candle basis.

A German firm, going back to the class of materials employed in the earliest attempt at the manufacture of incandescent electric lamps, has produced a lamp with a wire of tantalum as the glowing body and with an efficiency greatly in advance of that of the established carbon filament. More recently still, various experimenters have succeeded in producing lamps with a filament of metallic tungsten which carry the standard of efficiency to a point far beyond that obtainable with either carbon or tantalum. Since the graphitized or "metallized" carbon filament has in this country become a regular commercial product, the properties of which are moderately well known, it is deemed best in this paper to take up more in detail the peculiarities or the properties of the tantalum and the tungsten lamps.

PROCESSES OF MANUFACTURE.

It is not necessary in this place to go into a discussion of the processes of manufacture of the filaments of the metallized carbon and of the tantalum lamp, nor of the appearance of the lamps themselves, since these have become quite well known. In the case of the tungsten lamp, certain peculiarities of the construction are made necessary by the properties of the tungsten filament itself. The metal tungsten (German "wolfram") while ordinarily reckoned as one of the rare elements, yet is from the point of view of lamp manufacture quite plentiful enough for all practical purposes. While its price per pound is high, yet considering the weight of the metal entering into an incandescent lamp, it is not especially expensive. One of its most important uses at the present time is the production of tungsten steel. The metal is infusible by any ordinary process. The melting point of tungsten filaments has recently been given by Waidner and Burgess* at 3200° cent. The metal is commercially obtainable in the form of a fine powder. Tungsten does not seem to be ductile, so it is impossible to draw it directly into a fine wire, as is done successfully in the manufacture of the tantalum filament. Tungsten unites readily with oxygen and with carbon at high temperatures. These peculiarities have made the problem of the production of tungsten filaments a rather difficult one. It has been attacked from several sides, and different processes for the manufacture of tungsten filaments have resulted therefrom.

The earliest process to be brought to public attention was that of Dr. Kuzel. Kuzel's process consists in the production of a colloidal solution of tungsten by forming an arc between terminals of the metal under the surface of water. The colloidal solution, when it has been brought to the proper consistency is squirted through a die into filaments, which after being dried are converted from the colloidal condition into the crystalline condition by the passage of an electric current through them. In this way the filament is produced without

*Journal of the Franklin Institute, 1905, vol. CLX, p. 21.

†Asheville Convention paper, 1905.

*Electrical World, 1906, vol. XLVIII, p. 915.

introducing any carbon, which would unite with the tungsten to form tungsten carbide, a compound which is readily formed and which is very detrimental to the quality of tungsten filaments.

Another process is the substitution process of Dr. Just and Hanaman. This process seems to be very similar to one patented by Lodyguine some ten years ago. In this process a very fine carbon filament is heated in an atmosphere of a chloride of tungsten and hydrogen. Under proper conditions of the experiment, tungsten is deposited upon the carbon filament, the hydrogen acting as a reducing agent. By heating the filaments by means of a current the whole filament is converted into tungsten carbide. The carbon made is then removed from the filament by heating the same in an atmosphere of steam and hydrogen. The steam is decomposed, its oxygen uniting chiefly with the carbon of the carbide. Whatever tungsten is oxidized in this process is reduced again by the hydrogen which is present. It is impossible to say exactly whether this process is actually used in the manufacture of these lamps or not, though the statement may be made with a reasonable degree of certainty that some substitution process is used by Dr. Just and Hanaman.

The manufacture of filaments of osmium presented a problem similar to that of the tungsten filament. It is, therefore, natural that the process of Dr. Auer von Welsbach should by proper modification be adapted to the manufacture of tungsten lamps. Experiments along this line have been carried on by the companies in Germany and Austria which have been engaged in producing osmium lamps. To the tungsten lamp manufactured by the Osmium Lamp Company of Vienna has been given the name of the Osmin lamp. The tungsten lamp of the Auer Company of Berlin is called the Osram lamp. While it is reasonably certain that the details of the processes of manufacture of these two lamps differ from each other, yet they are probably alike in their general features. The method consists in forming a paste of finely-divided tungsten with a binder of organic material such as, for instance, sugar solution, and squirting the same into filaments through a die. The carbon is then removed from the filaments by heating the latter in an atmosphere of steam and hydrogen or by the use of some similar process.

Still another tungsten lamp is known as the "Z" lamp. The process by which it is manufactured involves also a squirting of a paste consisting of finely divided tungsten with an organic binder, but differs from the other in the method employed to remove the carbon.

A well-known manufacturing company has announced that it is about to put a tungsten lamp upon the market, made by a process differing from all those mentioned above, but no information as to the nature of this process is available.

It has also been announced that Mr. John A. Heany has been successful in producing tungsten lamps, but details as to his method of operation are also entirely lacking. Some lamps made by Mr. Heany have been the subjects of experiments made at the National Bureau of Standards.*

It will be seen from the foregoing that the possible methods for producing tungsten lamps are probably quite numerous, and that the prospects are that we shall have in the near future a number of competing processes of varying degrees of merit. Time and experience will be required to show which is best adapted to practical application.

PHYSICAL CHARACTERISTICS.

Tungsten lamp filaments manifest all the ordinary properties of wires of pure metals. They have high conductivity and a large positive temperature coefficient. The high conductivity of the material requires that the filaments shall be very fine and quite long if they are to be used in producing lamps giving a reasonably low candle-power on 110-volt circuits. The degree of fineness to which it has been possible to reduce these filaments is indicated by the following table:

		Diameter
Tantalum,	110 volt, 22 c-p	0.052 mm.
Osmium,	16 volt	0.103 "
Z	New	0.1 "
Z	After burning	0.055 "
Osram,	After burning	0.044 "

A fine hair may have a diameter of about 0.06 mm. In view of the extraordinary degree of fineness which has already been attained in the manufacture of these filaments it does not seem probable that very much more can be looked for in this direction.

Tungsten filaments, when at the temperature of full incandescence, are quite soft. It is, therefore, not feasible to produce them and mount them in lamps in any other form than in loops. In this lamp the filament consists of four loops. The ends of each loop are attached by means of a paste or by actually fusing them fast by the use of an electric arc to wires brought out from the stem of the lamp. The stem of the lamp is prolonged and carries at its lower extremity wires which serve as guides and supports for the loops of the filament. All the lamps which have been exhibited up to the present time have

*Electrical World, loc. cit.

been intended for burning only in a pendant position. It can be stated, however, that by certain modifications in the details of construction lamps are now being made which can be burned in any position. The first tungsten lamps produced were designed for low voltages. In consideration of the high conductivity of the material, the production of a low-voltage lamp is a more simple problem than the production of one of higher voltage, since for low voltages a shorter length of the filament may be employed. It would seem also that it is easier to produce a lamp of high candle-power than of low candle-power, since a stouter filament may be employed in the high candle-power lamp.

As far as the writer knows, no 110-volt lamps have been produced as yet for lower candle-powers than 25 and no lamps have been produced for higher voltages than 220. The fineness of the 110-volt, 125 candle-power filament is such that it would seem to be difficult to produce such a lamp as a regular commercial article. The 220-volt lamps are probably only experimental as yet. The properties of the tungsten filament are such that it would seem to lend itself very readily to the production of most excellent lamps for street lighting by the series incandescent system. Lamps for 110 volts are likely to have when commercially produced a watt consumption of 50 watts or more. If tungsten lamps are to be made for small candle-powers, such as are commonly employed in domestic lighting, they would probably need to be made for 50 volts or under, and consequently either burned in series or connected to low-voltage mains.

One of the chief disadvantages of the tungsten lamp lies in the extreme fragility of its filament. Blows or shocks given to the lamp are quite likely to cause a rupture of the filament. A ruptured filament may, however, mend itself by the parts welding together once more, but where the filament has become welded it is quite likely to break loose again.

ELECTRICAL CHARACTERISTICS.

The feature which differentiates the electrical behavior of the newer lamps from the ordinary carbon lamp is their positive temperature coefficient. The temperature coefficient of the ordinary treated carbon filament has been shown by Mr. John W. Howell to be very nearly zero at the temperature of ordinary incandescence. At lower temperatures its coefficient is negative. The term "metallized" has been given to the carbon filaments treated by the high-temperature process on account of the fact that these filaments at their temperature of incandescence have a positive coefficient. The tungsten and tantalum filaments have also positive coefficients which are, moreover, much larger than the positive coefficient of the "metallized" carbon. The temperature coefficients of tantalum, osmium, and tungsten filaments have been determined by measuring the resistance of these filaments at room temperature and again at 100 degrees centigrade. The coefficients as found were as follows:—

Tantalum	...... 0.234	per cent. per degree
Osmium	.... 0.372	" " " "
Tungsten (Osram lamp)	...... 0.438	" " " "

It will be noted that the temperature coefficient of the osmium filament corresponds very closely to the temperature coefficient of pure platinum. The temperature coefficient of the tungsten lamp is higher and that of the tantalum filament is lower than the average coefficient for pure metals. In accordance with the general law that the presence of impurities reduces the temperature coefficient to a very marked degree, it would appear that the tungsten of the Osram lamp was very pure, while the tantalum of the tantalum lamp either contained some slight trace of impurity or the metal was in such a condition, due possibly to crystallization or to lack of annealing, that its coefficient was abnormally low.

The effect of the positive coefficient is to give the metal-filament lamps considerable inherent regulation. That is, the change of current through the lamp is no longer proportional to the change in voltage, but is smaller proportionally than the change in voltage. Consequently in watts, candle-power, and watts per candle of these lamps undergo smaller changes with the change in the line voltage than is the case of the carbon-filament lamp. These characteristics are brought out in the curves of Fig. 2.

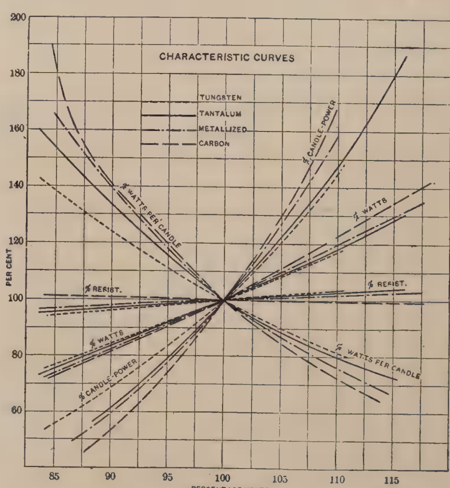


FIG. 2.

From the data used in plotting the above curves the following table has been taken which shows the change in candle-power and in the watts per candle of carbon, metallized tantalum, and tungsten lamps with 5 per cent. rise in the voltage.

TABLE III.

CHANGE WITH 5 PER CENT. INCREASE IN VOLTAGE ABOVE NORMAL.

	CANDLE-POWER	WATTS PER CANDLE
Carbon	+30%	—15%
Metallized	+27%	—13%
Tantalum	+22%	—11%
Tungsten	+20%	—10%

The quality of the lamps here pointed out is a very valuable one, since it must have two important results:

1. The light of the lamps is less affected by bad regulation of the circuit. This means that with a given degree of regulation of the voltage on the circuit, the service must be more satisfactory to the user, and has a direct bearing on the amount of copper required in feeders.

2. The life of these lamps is probably less affected by the momentary or even continued application of excessive voltages.

Another interesting consequence of the positive temperature coefficient is that at the instant of closing the circuit the current through a metallic filament is much greater than it is a fraction of a second later when the current has had time to heat the filament to its normal temperature. In other words, there is an initial inrush of current similar to that experienced in an arc lamp or in a motor, but enduring for a much smaller period of time. The behavior of the ordinary carbon filament is the reverse of this. This effect is clearly shown in the oscillograph curves of Fig. 3, in which one record shows the initial current through a carbon filament and the other the initial current through a tantalum filament.

FIG. 3.

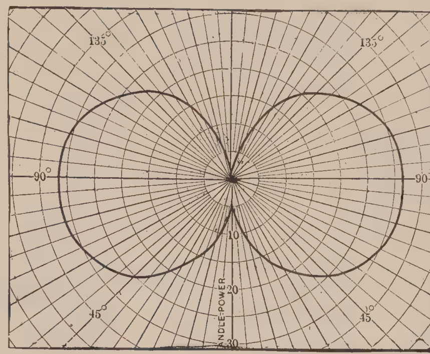


FIG. 4.

The position of the two spots of light before the circuit was closed is shown at the right of the figure. On closing the circuit, the instantaneous value of the current through the tantalum lamp is very high, but decreases with great rapidity. The instantaneous value of the current through the carbon filament is much lower, and gradually reaches its maximum value. The consequences of this can be perceived by the eye. Since the initial inrush into the metallized filament causes it to come to full incandescence much more quickly than does the carbon filament, the relative sluggishness of the carbon filament is readily appreciated by the eye when the metallic filament and the carbon filament lamps are lighted up side by side on the same circuit.

DISTRIBUTION OF LUMINOUS INTENSITY.

The distribution of luminous intensity in the horizontal plane for both tantalum and tungsten lamps must be on the average a circle, due to the method of construction of the lamps. This circle contains in each case a number of narrow maxima which are due to reflections from the opposite side of the bulb. Curves of vertical distribution of a tungsten lamp and of a new and an old tantalum lamp are shown in Figs. 4 and 5. The differences between the curves of the old tantalum lamp and the new tantalum lamp bring out a marked peculiarity of the tantalum lamp when constructed with a straight-sided bulb. It points to a change in the spherical reduction factor or ratio of the mean spherical to the mean horizontal candle-power of the lamp during its life. Such a change is actually shown by the lamp. The change in vertical distribution may be traced to two causes; first, to the fact that during the course of the burning of the lamp a

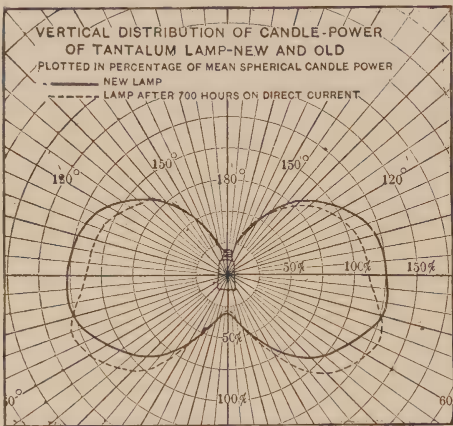


FIG. 5.

heavy deposit of black material is left on the bulb in a zone of a width substantially the same as the length of the spires of filament stretched between their support. This zone of blackening decreases strongly the horizontal intensity of the lamp, and much less strongly the intensity in the direction of the tip. Hence, the candle-power as measured through the tip becomes relatively stronger as time goes on.

Another cause of this change is probably the increased roughness of the filament of the lamp. When the lamp is new, the filament appears as a fine smooth wire, looking like polished steel, and showing, under the microscope, a uniform surface, except for very slight pittings. A wire of this sort would radiate very little in directions nearly parallel with its length. The law which applies to a body having a perfectly black surface is that the radiation is proportional to the cosine of the angle of emission of the rays. The radiation from such a body as the tantalum filament would decrease more rapidly than according to this cosine law, consequently there would be a deficiency of light in directions not at right angles to the filament. The filament, however, becomes roughened with use, and the little projecting surfaces would tend to increase the radiation in these directions.

The spherical reduction factors for twenty tantalum lamps, as shown in Table IV are extremely variable, falling as low as 0.69 and rising as high as 0.76. The cause for this is probably in the difference in the degree of polish of the surface of the filament. A lamp having a filament in the form of a straight cylindrical rod of perfectly black surface would show a theoretical reduction factor of 0.785. Practical carbon-filament lamps never have a factor smaller than this. A lamp of this character would give no light through the tip. The fact that the tantalum lamp shows smaller reduction factors than this value indicates how comparatively feeble is the radiation of this polished wire in other directions than normal to the surface. The value of this reduction factor shows, however, a very large increase during the life of the lamp, as is seen from the table, the change amounting, in some cases, to over 30 per cent. This is leaving out of consideration lamps which show an abnormal change in reduction factor, due to short circuits among the spires of the filament. These changes represent the combined influence of the roughening of the filament and of the deposit of the zone of black on the bulb so as to intercept the horizontal rays. An important conclusion from the facts here noted is that it is absolutely necessary, if we are to obtain any adequate idea of the performance of the tantalum lamp, to make measurements of the mean spherical rather than of the mean horizontal candle-power. Measurements of the horizontal candle-power alone, the spherical reduction factor being unknown, are likely to be misleading and fallacious. This is not the case with the carbon filament, in which the spherical reduction factor is quite a definite and unvarying quantity for a given type of filament.

"USEFUL" LIFE OF METAL-FILAMENT LAMP.

It has been customary to consider as the useful life of a carbon-filament lamp its life up to the time when its candle-power has fallen to 80 per cent. of its initial value. Beyond this point it has been considered cheaper to discard the old lamp and replace it with a new one; in other words, this has been taken to be the proper "smashing point" of the lamp. It should be pointed out that this relation does not hold with the metallic-filament lamps. The smashing point of a lamp is determined by considerations of initial cost of the lamp, the cost of electrical energy, and the rate of decline of the candle-power. In the metallic filament lamps we have lamps of much higher economy, not only initially, but throughout their life; they are lamps of higher candle-power and necessarily of higher initial cost. It would seem that the data at present available regarding such lamps are not sufficient to permit of the proper determination of the smashing point. Certain it is, however, that where such lamps are used they are likely to be burned until they fail. This is the condition which is almost necessarily brought about by their relatively high cost.

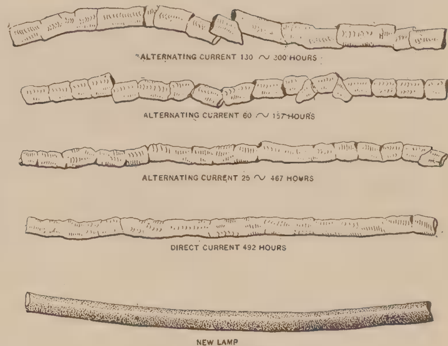
A feature which marks both the tantalum and the tungsten lamp is the ability of the filaments sometimes to repair themselves after having been broken. If the broken end of a filament becomes crossed

with another portion of the filament so that the electric circuit is completed the lamp once more lights up. In the case of the tantalum lamp, a junction of this kind may result in a very strong weld, so that a point of this sort does not necessarily constitute a point of especial weakness in the filament. Welds of this sort between tungsten filaments operated at normal voltages are much less secure and are quite liable to break apart. After a repair of this sort the candle-power of the lamps is usually higher than before, due to the decreased length of filament which the current must traverse. The occurrence of breakages and repairs accounts for irregularities in life-test curves such as are not seen in the curves of carbon filament lamps. This peculiarity of the metal-filament lamps raises a question in regard to proper criterion for reckoning the life of such lamps when testing them. The question is, should the life of a metal-filament lamp be reckoned up to the time when its filament first breaks or should the time of final failure be taken? In other words, should the first natural failure be considered as terminating the useful life of the lamps, or should the useful life include all the period up to the point where it is no longer possible by manipulating the lamp to cause it to repair itself?

LIFE HISTORY.

Some of the earliest tests of tantalum lamps made in this country showed a much poorer behavior than was claimed for the lamp by its makers. In these tests the lamps were burned on alternating-current circuits. Since there was no reason to suspect that the lamps were suffering on account of incorrect voltage or rough handling, the conclusion was almost inevitable that the nature of the current might be influencing their life. On trial it was found that tests made on direct current instead of alternating gave results which were in general agreement with those which had been published abroad. Since that time the effect of alternating current in shortening the life of a tantalum lamp has become well recognized. Since no quantitative data have been published showing the amount of this effect, the following table in which comparative values of the life of tantalum lamps on direct current and on alternating current of 25, 60 and 130 cycles per second will be of interest. The results of the 130-cycle test have kindly been placed at my disposal by the authorities of the Edison Lamp Works.

A microscopic examination of the tantalum filaments, new and burned on direct current of different frequencies, is extremely interesting. A free-hand drawing of such filaments as seen under the microscope is given in Fig. 6. It will be seen in this figure that the unused filament is smooth and polished with only slight pittings on the surface. The filament which has been burned on direct current is much less regular; its surface shows deeper pittings and, in places, it is cut and notched as if with a knife blade. Some parts of the filament are much more irregular than others. The filament on 25 cycles shows still stronger markings of the same character as shown on the direct current, but shows also, in places, a jointed structure looking like the jointed structure observable sometimes in basaltic rocks. This latter effect is even more marked in the case of the filament which has been run on 60 cycles. Here, parts of the filament look as if they were made up of blocks which had been irregularly piled one on the other. The length of these jointed sections in the filament is about equal to the diameter of the filament itself. It looks, in some places, as if one of these sections had been almost expelled from the row. The appearance, too, is very much as if where these joints occur, the filament had actually separated and had welded itself together instantly. The filament which had been operated on 130 cycles had the same appearance, perhaps somewhat exaggerated. In short, the increased wear and tear of the filament, due to the use of the alternating current, is very apparent. The reason for it, however, is obscure. The conclusion is inevitable that this lamp at the present time is essentially a direct-current lamp.



THE TANTALUM FILAMENT

FIG. 6.

No such effect is observable with the tungsten lamps. Tests of the Electrical Testing Laboratories show quite definitely that their life on direct current and alternating current is the same. This has also been proved by elaborate experiments to be true of carbon filaments.

The results of tests of 20 tantalum lamps of German manufacture on direct current are given in Table IV. From these data the curves of Fig. 7 have been plotted.

TAPLE IV.

DATA ON TEST OF GERMAN-MADE TANTALUM LAMPS ON DIRECT CURRENT.

Lamp No.	Mean Hor. c-p. Init.	Mean	700 hr.	Watts per c-p. Init.	Mean.	700 hr.	Hor. c-hr.
51	23.0	23.7		2.04	1.99		12233
52	24.4	23.9		1.98	1.98		7349
53	21.1	21.8	17.8	2.17	2.13	2.50	15284*
54	23.5	22.6	18.7	1.95	1.94	2.42	16026*
55	25.5	21.9		2.05	2.28		13706
56	24.5	24.1		1.94	1.97		10427
57	25.2	26.9		1.83	1.72		4844
58	24.0	21.3		1.93	2.11		13685
59	23.4	26.4		1.91	1.70		13765
60	24.6	26.4		1.87	1.73		10876
61	23.7	20.6	15.7	1.94	2.20	2.80	14416*
62	24.5	21.9	16.3	1.96	2.12	2.77	15374*
63	23.3	20.9		2.19	2.41		13133
64	23.9	23.0		1.98	2.00		11303
65	24.1	21.7	17.0	1.94	2.13	2.62	15184*
66	23.2	21.2	15.8	2.04	2.14	2.83	14816*
67	21.8	20.3		2.13	2.30		14226
68	24.1	22.7		2.00	2.06		12231
69	24.2	21.2	17.3	1.98	2.21	2.74	14830*
70	25.3	21.4	19.3	1.92	2.22	2.50	14990*
Average	23.9	22.8	17.20	1.99	2.07	2.65	12935

Lamp No.	Sph. Red Factor. Init.	636 hr.	Mean Sph. c-p. Init.	700 hr.	Decrease.	Watts per m.s. c-p. Init.	708 hr.	Increase.	No. of Short Circuits.	Life to B. O.
51	0.734		16.9			2.78			2	516
52	0.744		18.2			2.66			2	307
53	0.764	0.856	16.1	14.8	8.1%	2.84	3.06	7.7%	1	738
54	0.715	0.878	16.8	17.1	—1.8%	2.73	2.73	0%	2	738
55	0.738		18.8			2.78			1	626
56	0.721		17.7			2.69			2	432
57	0.715		18.0			2.56			2	180
58	0.736		17.7			2.62			2	641
59	0.760	0.886	17.8			2.52			1	642
60	0.730		18.0			2.56			1	412
61	0.738	0.938	17.5	14.3	18.3%	2.63	3.10	17.9%	1	
62	0.726	0.888	17.8	15.4	13.5%	2.70	2.95	9.3%	1	706
63	0.730		17.0			3.00			2	629
64	0.726		17.3			2.73			1	492
65	0.688	0.864	16.6	15.4	7.2%	2.82	2.92	3.6%	2	
66	0.716	0.909	16.6	17.3	—4%	2.85	2.71	—4.9%	2	758
67	0.742	0.924	16.2			2.87			2	700
68	0.727		17.5			2.75			1	539
69	0.707	0.902	17.1	19.8	—13.5%	2.80	2.53	—9.6%	3	738
70	0.711	0.925	18.0	18.7	—3.7%	2.70	2.66	—1.5%	3	737
Average	0.728	0.897	17.4	16.6	3.0%	2.78	2.60	2.8%		

* Candle-hours to 700 hours.

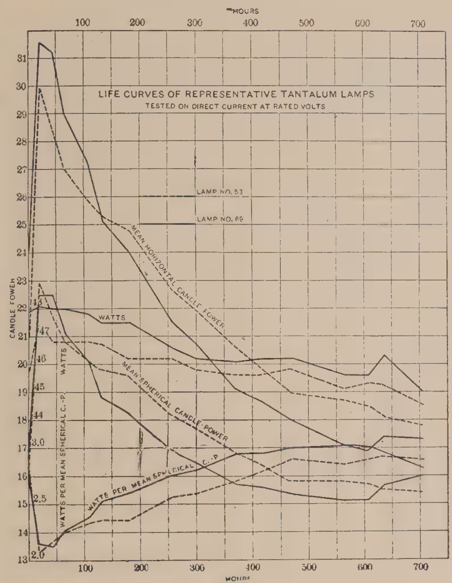


FIG. 7.

Representative lamps, the performance of which may be considered to be characteristic of the 20 tantalum lamps, have been selected from among the above. Data on these lamps are given in Table V and are plotted in Fig. 8.

From the foregoing data it will be seen that the life-history of tantalum lamps is characterized by a large initial increase in candle-power and a corresponding decrease in watts per candle, the extreme values being reached at the end of about 25 hours. From this point on, the candle-power decreases at a moderately rapid rate and the watts per candle increase. The rate of decline of the mean horizontal candle-power is more rapid than that of the mean spherical candle-power, for the reasons given above. The result of the relatively slow decrease of mean spherical candle-power with a large initial increase. is that in some cases the final mean spherical candle-power

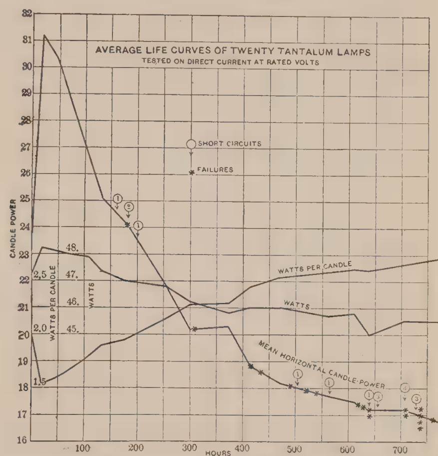


FIG. 8.

TABLE V.

REPRESENTATIVE TANTALUM LAMPS. DATA ON LAMPS NOS. 69 AND 53.

	Mean Horizontal. Lamp No. 69.	Mean Horizontal. Lamp No. 53.	Mean Spherical. Lamp No. 69.	Mean Spherical. Lamp No. 53.
Initial candle-power	24.2%	21.1%	17.1%	16.1%
Peak candle-power	31.6%	29.9%	22.5%	22.9%
700-hr. candle-power	17.3%	17.8%	16.0%	15.4%
Average candle-power to 700 hours	21.2%	21.7%	17.1%	17.6%
Decrease c-p. during 700 hours — From Initial	28.5%	15.6%	6.4%	4.4%
Decrease c-p. during 700 hours — From Peak	45.3%	40.5%	28.9%	32.7%
Rate of decrease per 100 hours during 700 hours — From Initial	4.07%	2.23%	0.91%	0.63%
Rate of decrease per 100 hours during 700 hours — From Peak	6.47%	5.79%	4.13%	4.67%
Initial reduction factor			0.764	0.707
Reduction factor at 635 hours			0.856	0.902
Average watts	46.6	45.8	46.6	45.8
Initial watts per candle	1.98	2.17	2.80	2.84
Watts per candle (peak)	1.52	1.59	2.12	2.07
Watts per candle (700 hours)	2.61	2.50	2.82	2.90
Average watts per candle	2.20	2.11	2.70	2.60

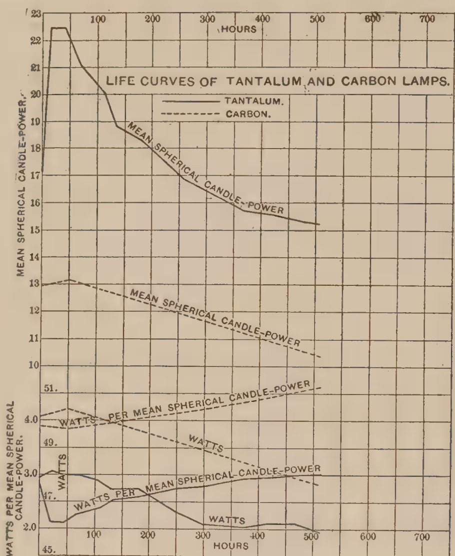


FIG. 9.

of a lamp is actually greater than its initial mean spherical candle-power. For purposes of ready comparison, life curves of representative tantalum and of a carbon lamp burned at 3.1 watts per candle are shown in Fig. 9. The candle-power of both is on a mean spherical basis. The exaggerated initial rise of the candle-power of the tantalum lamp is very apparent. Curves for watts per spherical candle-power give an opportunity for a comparison of the relative electrical economy of the two kinds of lamp.

Results of tests of tunsgten lamps made in various laboratories are given below. The data on some of the makes of tungsten lamps are extremely meager, a circumstance which in some cases is believed to correspond to a backward state of their

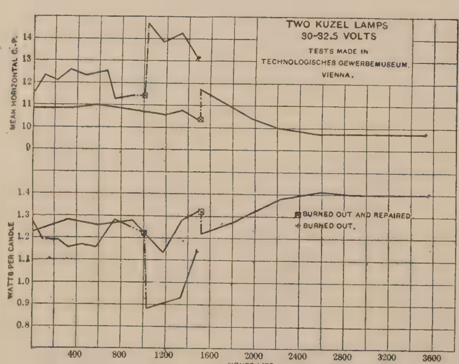


FIG. 10.

commercial development. Fig. 10 gives the results of tests* of two Kuzel lamps of approximately 30 volts and 11.5 candle-power, made at the Technologisches Gewerbe-Museum in Vienna. These lamps consumed approximately 1.25 watts per candle initially. One of them reached the extraordinary life of 3,537 hours, with a decrease in candle-power of about 10 per cent. The filaments in both the lamps were burnt through and repaired once in the course of their life. The result of the repair was an increased candle-power, which is shown clearly on the curve.

The average result of tests of three Osmin lamps of 55 volts and 44 candle-power are shown in Fig. 11. These tests were made in the laboratory of an electrical company in Vienna. The lamps showed a life of 1,200 hours and a decrease in candle-power of 14 per cent in that time. The results of a test of three Osmin lamps of

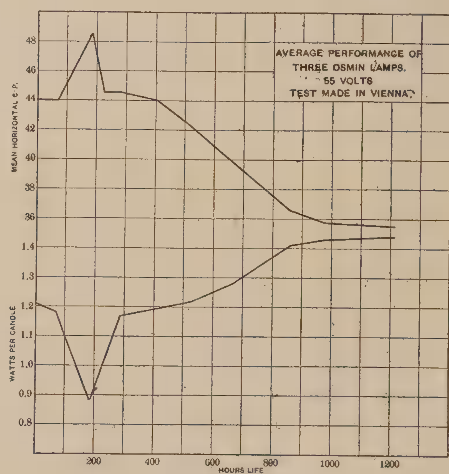


FIG. 11.

55 volts made at the Municipal Electricity Works, Vienna, showed an initial candle-power of 27.3 and initial watts of candle-power of 1.25. After 2,239 hours of burning the candle-power was 23.4 and the watts per candle 1.45. Six 54-volt Osmin lamps tested at the Technologisches Gewerbe-Museum consumed initially 1.17 watts per candle. After 1,776 hours the watts per candle were 1.24. The candle-power of these lamps is not given in the report. It should be noticed that all the above lamps are low-voltage lamps, from which a better result is to be expected than from 110-volt lamps.

The results of tests made at the Reichsanstalt of 16 Osram lamps of from 117 to 111 volts and 25 to 30 candles are shown

*Kremenezky "Electrotechnik und Maschinenban," 1906, No. 9.

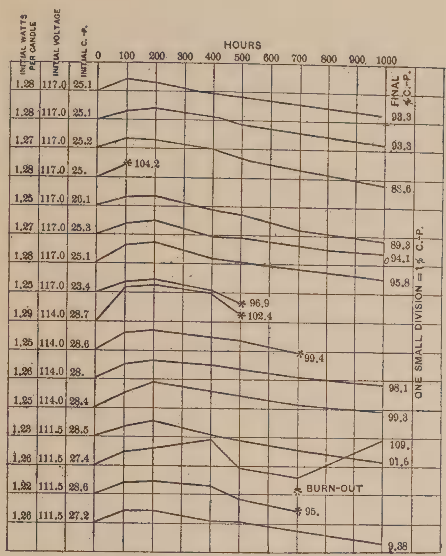


FIG. 12.

in the curves of Fig. 12. This test extended for 1000 hrs. In the course of that time 5 out of a total of 16 lamps had failed, while 11 lamps were still burning. The characteristics of the lamps seem to be a moderate initial rise in candle-power and a very slow subsequent rate of decline.

Fig. 13 shows average values of candle-power, watts, and watts per candle of eight 117-volt lamps from among those given in the above tests.

In Fig. 14 are shown the individual curves of six Osram lamps of 32, 35, and 45 c-p, testea at the Electrical Testing Laboratories. The results of these tests differ from the results of the Reichsanstalt test in that they show practically no initial rise in candle-power. The decrease in candle-power of the lamps throughout life, however, is very slow. The watts per candle are also almost constant. The life of the lamps was on the average considerably shorter than the life of those tested at the Reichsanstalt.

Candle-power curves of eleven tungsten lamps of quite another foreign make as tested at the Electrical Testing Laboratories are shown in Fig. 15. These lamps exhibit a very large initial increase in

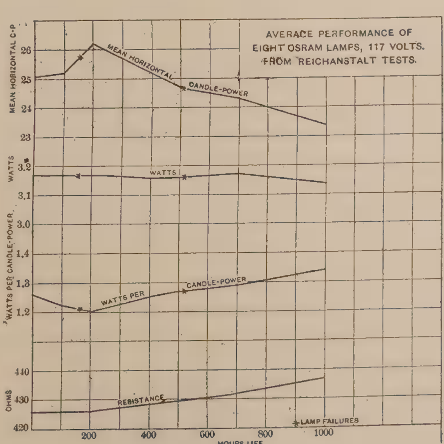


FIG. 13.

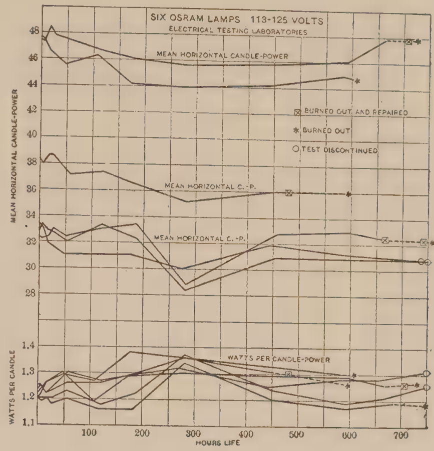


FIG. 14.

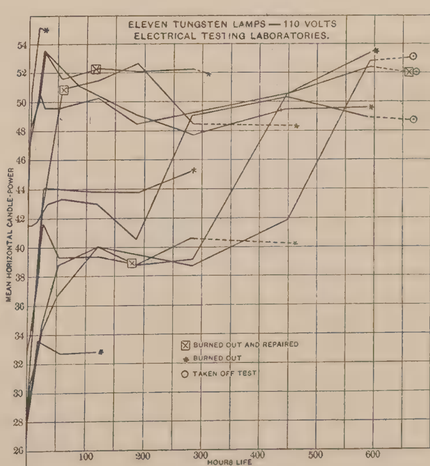


FIG. 15.

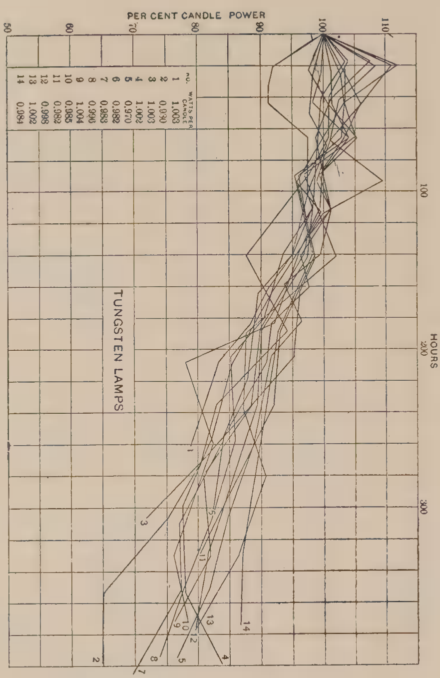


FIG. 16.

candle-power, followed by a practically constant condition. The average life is also much shorter than in the case of the Osram lamp.

The curves of Fig. 16 are of particular interest since they show the performance of lamps made in this country. These lamps were tested at an average initial consumption of 0.99 watts per candle. Their average life was 363 hours even at this high initial efficiency, and the average decrease in candle-power was 17.7 per cent. These curves demonstrate that incandescent lamps can be produced which will operate successfully at one watt per candle and will give a satisfactory life. The candle-power of these averaged about 40.

COLOR OF LIGHT AND EFFICIENCY.

The color of the light from the tantalum lamp is whiter than that of the carbon lamp, and the color of the tungsten lamp is still whiter than that of the tantalum lamp. The light of the tungsten lamp resembles quite closely that of the acetylene flame. The increased whiteness of the light, which is produced evidently largely as a temperature effect and which does not involve a preponderance of certain colors, such as green or violet, constitutes a point of real superiority in the tungsten lamp. Time has been lacking to make a regular spectrophotometric study of these lamps. A simple experiment, however, has been made which gives some idea of the increased radiation of the shorter wave lengths, both of tungsten and tantalum lamps, as compared with the carbon lamp at 3.1 watts per candle.

The metal-filament lamps were photometered against the 3.1-carbon lamp directly and then with a red, green, and blue glass interposed between the eye and the eyepiece of the photometer. The intensities so measured, expressed in percentages of the intensities measured without colored glasses, are given in the following table:

TABLE VII.

	TANTALUM LAMP.	TUNGSTEN LAMP.
Total light	100%	100%
Red light	90.5	83.0
Green light	100.3	101.8
Blue light	109.2	126.5

The increased whiteness of these lamps may theoretically be due either to higher temperature of the filament or to selective radiation by the filament. Recent work of Waidner and Burgess indicates that while the increase in the efficiency of tantalum and tungsten lamps, as compared with the carbon lamp, is to some extent due to the selective character of their radiating power, yet the chief cause of the increase is the higher temperature at which it is practicable to operate them. The higher temperature causes the maximum of the spectral energy curve to be shifted toward the shorter wavelengths, and consequently a higher percentage of the total radiation is emitted in wave-lengths which are capable of exciting vision.

FLICKERING ON ALTERNATING CURRENT.

It has been established as a result of practise that in general it is not possible to operate incandescent lamps on 25-cycle current with satisfactory results. This statement is made with a knowledge of the fact that in certain cities a large amount of lighting is actually being done on 25-cycle circuits. Yet under some circumstances 25-cycle current produces such marked flickering of incandescent lamps that its use is absolutely impossible. It is an interesting question whether the tungsten lamp presents any advantages over the carbon lamp for use on low-frequency circuits. Its positive temperature coefficient and the relatively low radiating power of its surface would tend to reduce the flickering, while the extreme fineness of the filaments which results in a smaller thermal capacity and the high thermal conductivity which, as a metal it probably possesses, would tend to increase the flickering. A

few preliminary tests have been made in an attempt to gain some information on this question. It was very quickly discovered, however, that the question is so very complicated that a considerable research will be required to ascertain definitely the facts of the case. Eleven tungsten lamps were attached to the ceiling of a small room, producing a brilliant illumination in the room. Three observers attempted to determine the presence or absence of flickering. With the lamps at their normal voltage of 115 and with a frequency of 25.5 cycles per second, L. found the flickering marked; M. found the flickering marked; S. could see a flickering intermittently, as when his head was moved suddenly. With the same lamps, but with the voltage reduced to 100, the flickering was imperceptible to all the observers.

As the voltage was raised successively to 105 and 110 volts the flickering became perceptible. When five of the lamps were removed, leaving only six lamps in position, it was the consensus of opinion of the three observers that the flickering was less marked than when all the lamps were in. In other words, the intensity of the sensation of flickering seems to be a function of the illumination. The flickering was imperceptible when looking directly at the lamps, but could be observed only through light which is not focused directly on the fovea of the eye. To institute a comparison between the flickering of the tungsten lamps and of carbon-filament lamps, two procedures may be taken.

1. To take a sufficient number of carbon-filament lamps of candle-power comparable to the candle-power of the tungsten lamps, lamp for lamp.

2. To take a sufficient number of carbon-filament lamps having a filament of approximately the same diameter as the diameter of the tungsten filament.

The numbers of the carbon-filament lamps must be so chosen as to give substantially the same amount of light as the tungsten lamps. The first of the two above alternatives was chosen for a comparative test. That is to say, twelve 32-c-p. carbon lamps were substituted for the 11 tungsten lamps. These were operated at 3.1 watts per candle. At the same frequency as was used for the tungsten lamps, no flickering could be observed. This is not a surprising result, since the diameter of carbon filaments is much greater than the diameter of the tungsten filaments, and consequently their thermal sluggishness is a much more important factor.

In view of the very considerable advantages which would be gained if it could be shown that it is feasible to operate incandescent lamps on alternating-current circuits of frequency low enough to permit of the easy operation of synchronous converters, that is to say, a frequency of 25 cycles or slightly greater, the question of the variation of the light of incandescent lamps during a half cycle of the alternating current has also been subjected to an experimental investigation by the use of a stroboscope. To the axis of a small synchronous motor was attached a disc with narrow radial slots cut in it, one for each pole of the motor. The lamp was placed behind this disc, while close to it and in front of the disc a suitable photometer was arranged. The motor was driven from one of two alternators, having their shafts coupled together, and the lamp supplied from the other alternator. The phase of the current passing through the lamp with respect to the current in the motor could be shifted through known angles by shifting the armature ring of one of the coupled generators. This generator arrangement, which was planned originally chiefly for meter tests, proved itself to be extraordinarily convenient for such stroboscopic measurements as are here described. With the use of this arrangement, curves have been plotted showing the variation in the intensity of the incandescent lamps as the current through the lamp rises from zero to its maximum value and decreases to zero once more. A set of curves of this kind relating to the metallized-filament lamp operated at 2.5 watts per candle, are reproduced in Fig. 17 and serve to illustrate the nature of the data obtained. Similar curves were obtained for ordinary 8- and 16-c-p. lamps, operated at a series of different values of the watts per candle.

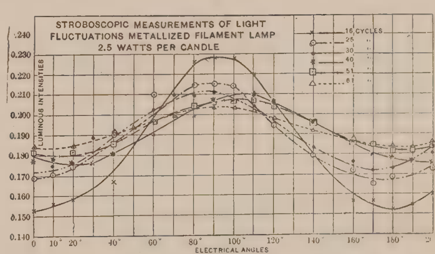


FIG. 17.

To discuss these results, the percentage variation of the light of the lamp per cycle was taken under all the different conditions. These percentage variations were plotted in curves shown in Figs. 18 and 19, using frequencies as abscissas. The curves so obtained, while exhibiting certain irregularities due to experimental difficulties, are fairly concordant and exhibit to a common character. The percentage variation seems from these curves to be expressed by two linear relations, with a point of sharp curvature occurring between 25 and 30 cycles

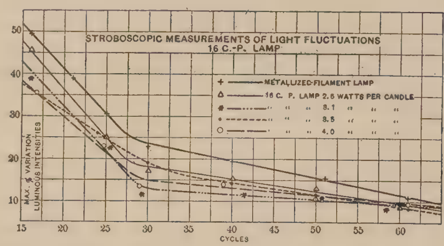


FIG. 18.

per second. That is, as the frequency is increased from 15 to 25 cycles the diminution in flicker is very rapid. Above 30 cycles the diminution in flicker is very slow. Since it has been found possible in some places to operate incandescent lamps on 25 cycles, it would seem probable that a comparatively small increase in the frequency, which would carry the lamps beyond this apparently critical point in the curve, might

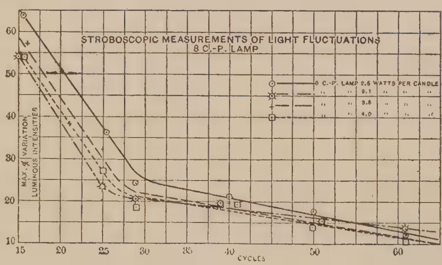


FIG. 19.

make feasible the general operation of incandescent lamps from alternating-current power circuits.

Similar tests to the above have been carried out on a 40-watt, 35-c-p, 115-volt Osram lamp. The results of this test as shown in Fig. 20 indicates that the stroboscopic variations of a tungsten lamp of this size are not much different from those of an ordinary lamp rated as an 8-c-p. lamp when forced to 2.5 watts per candle. The stroboscopic measurements, however, may be subject to certain ones of the difficulties which affect the detection of flicker by the eye. In other words, the degree of intensity of the light upon the photometer disc may have an influence on the results obtained. However, if the results of this preliminary test, which has been made in a very limited time for the purposes of this paper, can be confirmed by later and more careful experiments, the tungsten lamp will be found to be less adapted to use on alternating circuits of low frequency than the standard lamp of to-day.

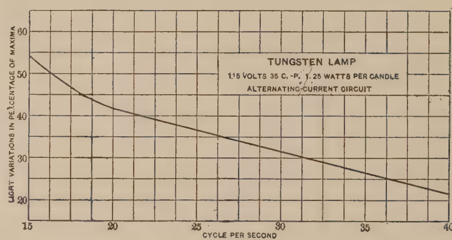


FIG. 20.

CONCLUSION.

From the data given above it seems certain that the electric lighting industry is face to face with a change of almost revolutionary character. The standard of incandescent lighting efficiency will be brought by the tungsten lamp to a point about three times as high as it is at present. The efficiencies of all other incandescent lamps and of enclosed arc lamps are exceeded by that of the tungsten lamp. In other words, with the possible exception of some forms of vacuum-tube lighting and of the magnetite and flaming arc lamps, the tungsten lamp is the most efficient electric illuminant. Combined with its virtue of high efficiency it has the other advantages of incandescent lamps in being perfectly simple in its character and construction and in being capable of subdivision into small units.

Review of the Technical Press

AMERICAN ITEMS

Tests of Incandescent Lamps, by Prof. L. B. Spinney: *Electrical World*, December 15th.

The article gives a condensed report of tests of something over 1,000 lamps representng 32 different makes, which were made at the Iowa State College for the purpose of determining among other things, the care with which commercial lamps are manufactured and selected. The writer maintains that low efficiency carbon filament lamps are used to a greater extent than is justified from the standpoint of economy, and says:

The fact that the practical operation of the carbon filament lamp requires the expenditure of, let us say, 3.1 watts per candle-power is scarcely to be regarded as justifying the use of lamps which consume twice that amount of power. Nevertheless, the most casual observation will convince one that such waste of power is not at all uncommon. Lamps that have been in service so long that their efficiencies have fallen to a low value and lamps rendered inefficient by being operated at voltages below that for which they were designed, are to be found perhaps upon every commercial circuit.

THE DETERMINATION OF THE MEAN HORIZONTAL INTENSITY OF INCANDESCENT LAMPS BY THE ROTATING LAMP METHOD

By Edward P. Hyde and F. E. Cady.
National Bureau of Standards, Washington.

There are several methods in use at the present time for the determination of the so-called mean horizontal intensity of incandescent lamps, i. e., the mean intensity in the plane perpendicular to the axis of the lamp and passing through its center. The oldest of these methods, and one which is equally applicable to other light sources, consists in measuring the intensity at equal angular intervals in the horizontal plane, and either taking the mean of the observed values, or plotting the observations and determining the mean radius vector of the curve drawn through the plotted points. A second method particularly adapted to the incandescent lamp because of the constancy of its curve of mean horizontal intensity was developed from the first method as an abbreviation of it. According to this second method photometric measurements are made in a single fixed direction, and the mean horizontal intensity is computed from mean horizontal "reduction factors" previously determined for the different types of lamps. Dyke has recently shown (1), however, that even for lamps of a single type of filament individual differences of such magnitude occur as to produce serious errors in the computed values of mean horizontal intensity. This fact in conjunction with the inconvenience of the necessary orientation of the lamps on the photometer bar in making the measurements has rendered the method of little practical value, and consequently its use at present is quite restricted. In a modified form of this method which is used in Germany, the direct light in a definite direction from the lamp is supplemented by light reflected from two mirrors placed behind the lamp and inclined at an angle of 120° so that an illumination is produced on the photometer screen which is approximately proportional to the mean of the intensities in the three directions. Liebenthal has shown (2) the possible errors incident to this method, for the types of lamps studied, to be as large as 5 or 6 per cent. when the lamps are definitely oriented, and 13 per cent. when the lamps are set at random.

A third method, and one which is in almost universal use in this country in all practical determinations of the mean horizontal intensity of incandescent lamps, consists in spinning the lamp about its axis at a uniform speed of 180 revolutions per minute. This suggestion of spinning the lamp is said to have been made by Prof. Chas. R. Cross at the National Electrical Congress held in Philadelphia in 1884, but the writers have been unable so far to find a record of such a suggestion. Thirteen years later the Committee on Standardization of the American Institute of Electrical Engineers, recommended (3) this method, suggesting a speed of 120 revolutions per minute. In recent years a speed of 180 revolutions per minute has been used quite

(1) *Phil. Mag.*, Vol. 9. p. 136, 1905.
(2) *Zeit. fur Instrumentenkunde*, Vol. 19, p. 193; 1899.
(3) *Trans. Amer. Inst. of Elec., Eng.*, Vol. 14, p. 90; 1897.

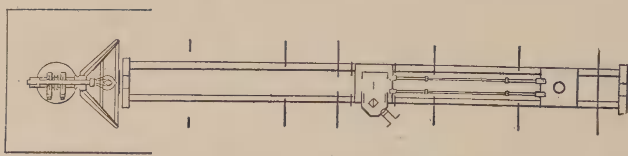


FIG. I.—DIAGRAMMATIC SKETCH OF PHOTOMETER BENCH, IN HORIZONTAL POSITION SHOWING ROTATING MIRRORS

universally, but an attempt to trace the authority for this modification has not as yet met with success.

A fourth method devised by Liebenthal ([4]) and used at the Physikalisch-Technische Reichsanstalt consists in rotating a pair of mirrors about the lamp held in a stationery position. The lamp is mounted with its axis horizontal and coincident with the photometric axis, the tip of the lamp being turned toward the photometer screen. The two mirrors, inclined at approximately 90 deg. to each other, reflect to the photometer screen light emitted from the lamp in a direction perpendicular to its axis. The direct rays from the tip of the lamp are prevented from reaching the photometer by a small screen. The mirrors rotate about the axis of the lamp and reflect to the screen a quantity of light proportional to the mean horizontal intensity of the source. This method necessitates, of course, the determination of the reflection coefficients of the mirrors, which is accomplished by means of a standard incandescent lamp whose mean horizontal intensity is known from a previous determination by the first method mentioned above.

Of the above four methods by far the most convenient in commercial testing is that of rotating the lamp, because but one measurement is required, and there is no question about the orientation of the lamp. Moreover by simple mechanical devices a reversal of the direction of rotation may be obtained so that lamps fitted with screw bases can automatically be screwed into and out of the socket, thus materially lessening the time required for measurement. Although the method of rotating the lamp is the most convenient it has been open to serious objection which has never been answered satisfactorily, so that while the method is in quite general use in this country, there are many who are in doubt in regard to its accuracy and its adoption abroad has been restricted.

The two possible sources of error of this method are (1) the possible distortion of the filament, (2) the effect of the flicker which is perceptible in nearly all types of lamps when rotating at 180 revolutions per minute, and which is extremely bad in those types in which the horizontal distribution curve deviates greatly from a circle. Besides the possible error produced by the flicker the accuracy of a setting is diminished considerably and the eye is rapidly fatigued.

In order to determine definitely the errors due to distortion of the filament and to the flicker, an investigation has recently been carried out in the Photometric laboratory of the Bureau of Standards. The results of this investigation will be discussed fully in the next number of the *Bulletin* (Vol. 2, No. 3). In the following paragraphs a brief résumé of the results will be given.

A pair of rotating mirrors (see Figs. 1 and 2) somewhat similar to those described above as in use at the Reichsanstalt, but with one essential difference, were constructed in the instrument shop of the Bureau. Instead of mounting the lamp in a stationery position between the mirrors, the apparatus was so designed that the lamp could be rotated about its axis, quite independently of the rotation of the mirrors. This arrangement obviated the necessity of a separate determination of the coefficient of reflection of the mirrors, which is liable to error unless the mean horizontal intensity of the standard lamp employed is obtained bv the point to point method from a very large number of readings. Although the rotating mirror system was made quite rigid the precaution was taken to show that the reflection coefficient of the mirrors was the same whether they were rotating or stationary.

The following series of observations was made with lamps of a number of different types: (a) mirrors rotating at a speed sufficiently high to eliminate flicker (in some cases over 800 revolutions per minute). lamp at rest; (b) mirrors rotating at 180 revolutions per minute, lamp at rest; (c) mirrors at rest, lamp rotating at 180 revo-

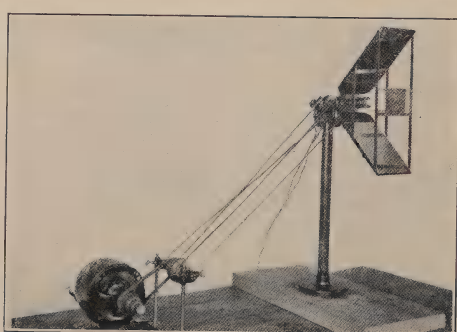


FIG. 2.—VIEW OF ROTATING MIRROR.

([4]) Loc. cit.

lutions per minute; (d) mirrors at rest, lamp rotating at 500 or 600 revolutions per minute; then the entire cycle in the reverse order. In all the measurements in order that the observer at the photometer should not be influenced by his readings, a second observer noted and recorded the settings on the bar, and the observer at the photometer was not informed of the results until the entire series of measurements had been completed. If there were no errors due to bending and no error due to flicker, all four of the above sets of readings would be the same. A comparison of (a) and (b) shows the effect of flicker separated from that of distortion of the filament; a comparison of (a) and (c) shows the combined error due to flicker and bending at 180 revolutions per minute. This combined error is that which occurs in practise when measurements are made on lamps rotating at 180 revolutions per minute. A comparison of (b) and (c) shows the effect of bending at 180 revolutions per minute; and a comparison of (a) and (d) shows the effect of bending at 500 or 600 revolutions per minute.

In all, ten different types of incandescent lamps were studied, including a 50-volt lamp, a 220-volt lamp, tantalum lamps and seven types of 110-volt carbon filament lamps. The results for the individual lamps will be reserved for the more detailed paper in the *Bulletin*. The general results can be stated briefly under the two heads, "Effect of Bending" and "Effect of flicker."

EFFECT OF BENDING.

At speeds of 500 or 600 revolutions per minute very appreciable changes in the mean horizontal intensity due to bending were observed, in some cases the effect being to decrease the mean intensity, in others to increase it. The greatest difference due to bending was observed in a "double carbon" filament which had accidentally been rotated for a few seconds at about 800 revolutions per minute and was afterwards brought to a speed of about 600 revolutions per minute. This lamp showed a decrease in mean horizontal intensity of about 2 per cent., but after the lamp was stopped rotating it was noticed that one loop of the filament had touched the bulb and had sealed itself there remaining permanently in that position. Except for this one lamp the greatest decrease in mean horizontal intensity at a speed of about 550 revolutions per minute was 1 per cent., which was the value obtained for another lamp of the "double carbon" filament type. The greatest increase in horizontal candle-power due to bending was about 0.8 or 0.9 per cent. for a "downward light" type of filament at 550 revolutions per minute. The anchored oval filament showed a slight decrease due to bending amounting to about 0.5 or 0.6 per cent. at 550 revolutions per minute. At a speed of 180 revolutions per minute the effect of bending amounted in no case to more than a few tenths of 1 per cent.

The tantalum lamp showed a queer effect which it is interesting to note in passing. Although one might expect a decrease in mean horizontal intensity on rotation, no such effect was found, the observations indicating a slight increase. The magnitude of the effect was small but since in every one of a number of determinations the sign of the effect was the same it is probable that there is a real increase in mean horizontal intensity. The peculiar feature to which attention should be called, however, is the apparent increase in resistance of tantalum lamps on rotating them. At least a half-dozen lamps were tested, each of them several times, and without exception, on rotating the lamps the current decreased although the voltage was maintained constant. The amount of change was not the same for all lamps, nor indeed the same at different times for any one lamp, but ranged from one per cent. to only a few tenths of one per cent.

EFFECT OF FLICKER.

The most surprising results of the investigation were found in studying the effect of flicker on the apparent mean horizontal intensity of the different types of lamps. The common oval anchored type of filament shows comparatively little flicker when rotating at 180 revolutions per minute, and consequently, when small differences between sets (a) and (b) were found they were ascribed to observational errors, since the difficulty of setting with a flickering light is much greater than when the fields of view in the photometer appear steady. When, however, with other types of lamps differences amounting to 4 per cent. occurred it became evident that the effect was not to be ascribed to the probable error of observation, for every one of 5 or 10 readings with the mirrors at high speed would lie entirely without the limits of the readings at 180 revolutions per minute. Moreover, with different observers the effect of the flicker was found to be quite different. Thus while one of the writers read the flickering light about 4 per cent. too high the other read it about 3 per cent. too low, a difference of 7 per cent. Moreover, each observer persisted in his habit so that when, about this time, a number of lamps submitted for test were measured it was subsequently found on looking over the results that while the values obtained by the two observers agreed excellently for most lamps, there were large differences, always in the same direction, for lamps in which there was a disagreeable flicker.

Other observers were tried, some of them experienced in photometry, and all experienced observers in other lines of physical investigation, but in almost every case there was a decided preference for either higher or lower values with the flickering light. All of the measurements referred to above were made with a Lummer-Brodhun contrast photometer, and in every case there was a color match on the two sides of the screen. Subsequently a number of measurements were made by three observers with a very good Lesson disk furnished the Bureau by the Electrical Testing Laboratories of New York. Strangely enough, with this photometer each of the three observers changed the sign of his error as compared with his measurements on the Lummer-Brodhun photometer. Of course the error of observation with a badly flickering light, such as is obtained with a "double flattened" filament or a "downward light" filament is quite large, but there is no question in the writers' minds but that the error due to flicker is a very definite one, characteristic of the individual. It would not seem, however, that the effect is a true physiological effect in the same sense as Talbot's law for non-flickering illuminations. It is not that different eyes integrate a flickering light differently, but rather that they do not integrate at all. The explanation would seem to be this: Due to inability of the eye to integrate a flickering light, an infinite number of different independent intensities are perceived. On any one of these a setting could be made, but having chosen some one point in the series of fluctuating intensities the criterion persists, and the more observations the individual makes the more probable it is that he will continue to set in the same way. One of the observers previously mentioned was conscious of two different criteria by either of which he was able to make consistent settings. According to one criterion he set too low; according to the other too high.

Apart from the explanation of the effect of flicker the important fact which the investigation makes clear is that, in the case of lamps in which the horizontal distribution curve deviates considerably from a circle so that a bad flicker results when the lamp is rotated at 180 revolutions per minute, some other method for determining the mean horizontal intensity must be employed. Otherwise large errors amounting to many per cent. may arise. Since all of the types of lamps investigated stood up very well under the high speed of 500 revolutions per minute and the effect of bending was in no case more than 1 per cent., it was thought desirable to invevstigate possible errors incident to the determination of mean horizontal intensity by rotating the lamps at a speed double that in use at present, i. e., at 360 revolutions per minute. Before doing this, however, some experiments were made on the mechanical effects of such a speed on lamps the filaments of which had drooped due to prolonged burning in a horizontal position. Three 50-cp, 110-volt lamps, each of which had burned several hundred hours and had fallen in intensity below 80 per cent. of its initial value, showed excessive drooping. In one lamp the filament was not more than 3 or 4 mm. from the bulb; in each of the other two the filament was about 5 or 6 mm. from the bulb. These lamps, which had long heavy filaments and which had given evidence of their susceptibility to bending under the influence of mechanical forces by their excessive drooping under the action of gravity, would seem to represent the most unfavorable case for a high speed rotation. The lamp in which the filament was within 4 mm. of the bulb stood a speed of 300 revolutions per minute. At about 350 or 400 revolutions per minute the filament touched the bulb, and melting it at the point of contact allowed air to enter which caused the lamp to burn out. The other two lamps were rotated at increasing speeds up to about 650 or 700 revolutions per minute before the filament touched the bulb, in each case the result of the contact being the same as before. Since these lamps would probably have been rejected on most specifications before dropping to 80 per cent. because of the excessive drooping, it would seem that a speed of 360 revolutions per minute would be quite safe in all practical cases. Although measurements made on different types of lamps indicated no determinate permanent change in the horizontal intensity the effect of continued burning while rotating at a speed of 360 revolutions per minute was not investigated.

After showing that a speed of 360 revolutions per minute would probably produce no serious mechanical difficulties, samples of those types of lamps in which the effect of flicker is most pronounced and of those in which the bending is greatest, were measured at that speed in order to see whether the errors due to flicker could be obviated without introducing prohibitive errors due to bending. It was found that in several types of lamps the flicker was still so pronounced that differences of several per cent. were obtained. It was therefore concluded that either a higher speed must be used, or some other method employed.

Since it would not seem feasible to increase the speed much above 360 revolutions per minute an attempt was made to devise some other method by which an increased accuracy could be obtained. The following considerations suggest a method which was put in practice and found to be quite satis-

factory. The error due to the flicker is a function not only of the speed but of the difference between the maxima and minima of the flickering light. No matter how great this difference, the flicker will cease at sufficiently high speeds, but if the difference is small the error due to the flicker will be relatively small at all speeds, and will entirely disappear when the speed has been increased even to a moderate value. In those types of lamps in which the error due to flicker was found to be large the differences between the maxima and minima are great, amounting in one type to 70 per cent., so that if in some way the extreme fluctuations in the intensity of illumination on the photometer screen could be lessened the resultant error would be diminished.

Except in the case of anomalous lamps extreme differences in intensity in different directions are not due to bad centering of the filament or to any effect connected with a displacement of the effective center of radiation from the axis of rotation—fluctuations due to these effects would in general be relatively small. The irregularity of the horizontal distribution curve is due primarily to the shape of the filament, and consequently, except for sharp reflections from the bulb, or sharp shadows produced by the obscuration of parts of the filament, the maxima lie 180 deg. apart, and the minima approximately at right angles to the maxima. Hence if to the illumination produced by the direct light from the lamp on the photometer screen, an illumination produced by light emitted in a direction normal to the photometric axis be added, the resultant illumination will show a relatively small variation on turning the lamp. If the lamp is rotated at the customary rate of 180 revolutions per minute the flicker will be much less disagreeable and productive of error than that incident to the direct light alone when the lamp is rotating at double this speed.

In order to accomplish the above result in practice a single stationary mirror was placed in such a position that light emitted at right angles to the photometric axis was reflected by the mirror and was incident on the screen in conjunction with the direct light from the lamp. Measurements made on the "downward light" lamp at 180 revolutions per minute by the two observers who had previously differed by about 7 per cent. at this speed showed an agreement well within the range of the error of observation which was probably less than one-half of one per cent. In a similar way the error due to flicker in all types of lamps in which the maxima and minima lie approximately at right angles to each other would become quite small even at a speed of 180 revolutions per minute. Although the results of the investigation at the Bureau show that a single mirror is sufficient for the types of lamps studied, it is possible that other arrangements of mirrors might be devised that would also eliminate the flicker.

One or two round bulb, "double round coil" filament lamps which had burned to 80 per cent. in life test, and which were unique in having most of the carbon deposit concentrated on a small part of the bulb showed bad flickers even with the addition of the mirror. This was to be expected, as measurements showed that, due to the absorption of the concentrated carbon deposit there was a difference of 40 per cent. between the intensity in the direction of the deposit and in a direction 180 deg. from the deposit. With such anomalous lamps a very high speed must be used or some other method employed, such, perhaps, as the addition of one of more mirrors. It would scarcely seem justifiable. however, to reject a very convenient method for a few sporadic lamps.

A more serious question is that of the practical applicability of the single stationary mirror method in consideration of the difference in path between the direct ray from the lamp and the ray by way of the mirror. The details of the mathematical investigation of this point will be reserved for a subsequent paper, but the result may be stated briefly. Assuming the two lamps at fixed positions, if the substitution method of measurement is employed (according to which the standard lamp is placed at the beginning of the measurements in the same position as the test lamps), and if in computing the candlepower scale a distance intermediate between the distance of the lamp and the distance of its image from the screen be taken as the effective distance of the lamp, the resulting errors for a large range of distance on either side of the middle point of the bar, will be entirely negligible. Of course with the mirror method a 32-cp lamp would be most convenient for use as a comparison lamp.

FOREIGN ITEMS

GLOW LAMP STANDARDS AND PHOTOMETRY

J. S. Dow.

From *The Electrical Magazine* Nov., 1906.

In the course of an article published in a recent number of *The Electrician*, the author gives some interesting comparisons of the several types of electric glow lamps so far as their suitability for the use as secondary photometric standards is concerned. Commenting in the first place on the respective merits of flames and glow lamps, the author indicates whereas the value of a flame standard is affected by the atmospheric conditions, accurate results could not be expected when using a flame-type standard for glow lamp tests, or *vice versa;* nor indeed, should an ordinary gas flame be depended upon for giving accurate results when used in conjunction with an incandescent gas burner. In short, the obvious fact is arrived at that the standard and the light under test should be similar in nature. This is, of course, well known, for then not only are the colors similar, but the affecting atmospheric conditions are common.

The author proceeds much further than this, and points out that even when lights of a similar type are compared, there are other factors than those of color and atmosphere which affect the accuracy of the tests. Thus he says: "It is to be, however, that as a rule two glow lamps, even of a similar class, are not affected by a change of P.D. in exactly the same way, and hence the ratio of candle-power of one to the other is distinctly affected by a change in the P.D. of 5 per cent. or so.

"For instance, the table below shows the result of comparing two 100 volt nominally 50 c.p. glow lamps when the run in parallel off several different P.D.s.

P.D. (Volts).	Ratio of candle power: Lamp No. 1. / Lamp No 2.
87.4	0.767
91.2	0.778
95.0	0.785

"A change of 1 per cent. in the P.D. would thus cause an error of something like 0.25 per cent. in the determination of the candle-power."

The necessity of maintaining a constant common P.D. when comparing metallic filament or Nernst lamps with the standard glow lamp is more important, as is shown by the author's figures below, which refer to a test of a tantalum lamp with a 100 volt glow lamp.

P.D. (Volts).	Ratio of candle power: Tantalum lamp. / Glow lamp.
91.2	0.576
95.0	0.530
97.0	0.505

The candle-power of an ordinary carbon-filament lamp varies with about the seventh-power of the P.D., the tantalum with the fourth power, the osmium lamp with the fifth power, whilst the Nernst lamp is practically independent of small variations of P.D.

It is pointed out that contact resistance in the lamp-holder is to be guarded against as introducing variations in the lamp P.D., that screw holders are to be preferred to those of the bayonet type, but that best of all is the Reichsanstalt method of overcoming any possible error on this account by measuring the current through the lamp instead of the P.D. at its terminals.

Another feature of photometric tests commented upon is that for accurate work a certain fixed distance between the lamps under comparison is desirable. The following table shows results obtained with a comparison of 16 c.p. and 8 c.p. Robertson lamps at different distances apart, other conditions being common.

Type of lamps compared.	Distance between lamps.	Ratio of C.P. 16 c.p. lamp. / 8 c.p. lamp.
Robertson 100 volt 8 c.p. and 16 c.p. lamps.	250cm.	2.38
	220 "	2.37
	200 "	2.35
	170 "	2.33
	140 "	2.34
	120 "	2.33
	100 "	2.32

The "hysteresis" effect or the change in c.p. following the "overrunning" of the glow lamp at a higher voltage than the normal or test voltage is dealt with by the author, who gives curves showing this effect in two instances, and also tabulated results.

The temperature of the test room affects candle-power of the standard glow lamp to the extent of 1 per cent. for a 9° C. change.

The article concludes with remarks as to the possible advantages attending the use of the new metallic filament lamps as

Type of Lamp.	Before Overrunning. At 95 volts. Current.	C.P.	At 110 volts, for 3 min. at 95 volts. Current.	C.P.	At 120 volts, for 3 min. at 95 volts. Current.	C.P.	At 130 volts, for 3 min. at 95 volts. Current.	C.P.
Sunbeam........	0.535	9.48	0.535	9.53	0.538	9.68	0.542	10.00
Robertson.......	0.543	9.70	0.544	9.72	0.545	9.70	0.550	9.97

photometric standards. "It seems likely that the study of some of the newer metallic filament lamps may lead to a greatly improved incandescent standard. The tantalum lamp, for instance, has the advantage that the candle-power is only proportional to about the fourth power of the P.D. across the lamp, while it seems likely that at low efficiencies its life would be distinctly better than that of glow lamps. On the other hand, the difficulty of producing such lamps for high voltages would be of little importance in the case of laboratory standard.

"Dr. Kuzel's metallic filament lamps, so far as may be judged from the information which has at present been published about them, might also prove valuable. The fall of candle-power with use at moderate efficiencies is said to be very much less than with carbon filament lamps, and, from the fact that the lamps are said to be very little affected by being overrun even 300 per cent., one would suppose that 'hysteresis effects' would be inconsiderable, and that such a standard would not easily be damaged by incautious regulation of the P.D."

A METHOD OF CALCULATING STREET ILLUMINATION

By Hugo Krüss.

From *Journal für Gasbeleuchtung*, Munich, Sept. 22, 1906.

In order to form a fair judgment regarding the efficiency of illumination of streets by means of various systems of light sources, it is necessary first of all to determine the actual value of the illumination by measuring with a suitable photometer, as Prof. Dreschmidt has done, for example.

It is also of value to reduce the distribution of illumination to figures, since inequalities in the operation of the lamps is not fully known, and furthermore it furnishes a theoretical standard by which the efficiency of the results may be judged.

I must first call attention to the intensity of illumination on a plane perpendicular to the street, since I believe, as Dreschmidt does, that the intensity on a horizontal plane is not as important as the intensity on a vertical plane. While reading or simply observing, one always takes such a position with regard to the plane of the street that he receives the best light possible, while it is the side turned to the observer, either coming or going, that comes into view of the persons approaching from an opposite direction. The case was very simple: the lamps were hung over the middle of the street, the test surface also over the middle at a height of h (Fig. 1) above the pavement.

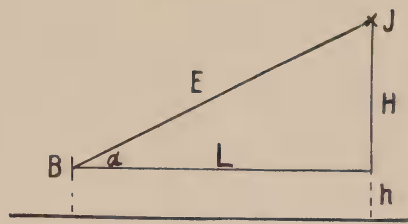


FIG. 1.

If the test surface is the distance L from the foot of the perpendicular drawn from the lamps to the street, and the height of the lamps above the test surface is H, the rays from the light source would meet the test surface at the angle a: then, tan

$$a = \frac{H}{L}$$

The distance E of the light source from the test surface, the intensity of which may be I, is then

$$E = \frac{L}{\cos a}$$

and the intensity B, which the test surface receives,

$$B = \frac{I}{E^2} \cos a = \frac{I}{L^2} \cos^3 a.$$

The angle of radiation from the lamps is evidently the same as the angle a on the test surface. If the test surface is at the distance D, Fig 2, sideways from the lamp, when one wishes, for instance, to compute the relative illumination on the sidewalk, E and a are in the right angle triangle of which L is the perpendicular on the test surface and another of which is made by the line F, which is drawn from the lamp perpendicular to the first perpendicular. The distance from F gives, according to the diagram, $F = \sqrt{D^2 + H^2}$ and the illumination intensity B from the equations above, in which the angle a is derived from the equation $\tan a = \frac{F}{L}$ In this case the angle of radiation B (measured below on the horizontal) differs from the angle of incidence a. It is

$$\tan b = \frac{H}{e}, \text{ in which } e = \sqrt{L^2 + D^2}.$$

In Fig. 3 the lamps are suspended over the middle of the street while in Fig. 4 the lamps are arranged alternately on the opposite sides. The intensity of illumination was estimated on a plane in the middle of the street, and also at the curb. In Fig. 4 in order to simplify the calculation, assume that a row of lamps is arranged perpendicular over the

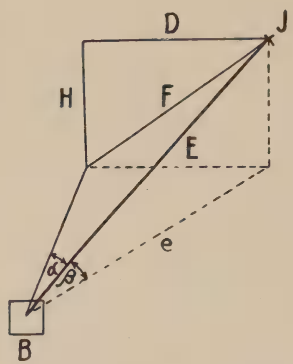


FIG. 2.

sidewise test line. The increase in the intensity on the assumed surface due to reflection from the walls of the buildings need not be considered? Presumably the increase is not very great in view of the fact that a surface illuminated by reflection from perfectly white cardboard receives, perhaps, only about ⅓ the intensity of the illuminated cardboard itself. However, very few of our buildings are white, many even having dark exteriors, while to a great extent the buildings in the business quarters have large plate glass windows on the ground floor and first story; so on account of these great irregularities it is better to eliminate this factor from the estimate.

In order to compare results, I calculated the illumination of Leipziger St., Berlin, as Dreschmidt had previously measured the relative illumination there. As the height of the test surface h is 1.5m.; then H becomes 7.5m. The lamps are placed at a distance of 30m. from each other (Dreschmidt 33m.), the distance of the curb from the middle of the street 6m. (Dreschmidt 5.5. and 5.7m.), and 2000 was assumed for the intensity I of the lamps; for all other

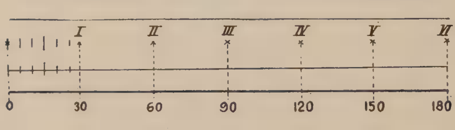


FIG. 3.

intensities, the figures may be changed proportionately. Also, since it was not necessary to calculate for any specified system of illumination, a light radiation the same in all directions was assumed. In the case of

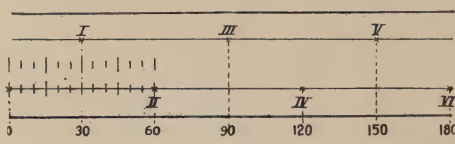


FIG. 4.

lamps placed over the middle of the street, the illumination of the test surface was determined for those locations where the lamps were about 5m. apart, the points being about a meter apart, beginning at the point directly below the lamp. If the test surface comes out beyond lamp I, the same set of figures is repeated. The results from lamps only, (I-VI) were determined, being unnecessary to continue the further calculation, since the more distant lamps leave an ever diminishing effect.

In the case of lamps suspended on alternate sides of the street (Fig. 4), the estimates had to cover 60m., since two lamps are arranged alternately here according to the same ratio; the points were taken, as in the previous case about a meter apart from lamps I and II.

In connection with this, it will be noted that the distribution of the illumination along the curb from the lamps suspended over the middle of the street is exactly the same as the distributing of illumination over the middle of the street from the lamps suspended on alternate sides of the street; since the intensity of illumination depends only on the distance of the light source and the angle at which it falls, and not upon the direction to right or left from which the rays of light come. The advantages of lamps suspended on alternate sides of the street in avoiding shadows along these alternate sides, does not belong to our discussion.

The foregoing figures and curves apply primarily to the conditions assumed; but they afford a method of solving another

Lamps and Test Surface Above the Middle of the Street.

Lamp	Angle of Radiation	Illuminometer Stations.										
		0	5	10	15	20	25	26	27	28	29	30
I	14 —90	2.03	2.81	4.10	6.36	10.24	13.66	13.03	11.39	8. 55	4.73	.....
II	7.1—14	0.54	0.64	0.77	0.95	1.19	1.56	1.61	1.70	1. 80	1 91	2.03
III	4.6— 7.1	0.24	0.27	0.31	0.35	0.40	0.46	0.48	0.49	0.51	0.53	0.54
IV	3.6— 4.6	0.14	0.15	0.16	0.18	0.20	0.22	0.22	0.23	0.23	0.24	0.24
V	2.8— 3.6	0.09	0.09	0.10	0.11	0.12	0.13	0.13	0.13	0.14	0.14	0.14
VI	2.4— 2.8	0.06	0.07	0.07	0.07	0.08	0.09	0.09	0.09	0.09	0.09	0.09
VII	....	....	....	....	....	....	....	....	....	....	....	1.06
	Total	3.10	4.03	5.51	8.02	12.23	16.12	15.56	14.03	11.32	7.64	3.10

Table I

Lamps above the Middle of the Street, Test Surface 6m from the Middle,
or
Lamps 6m from the Middle Test Surface Above the Middle of the Street.

Lamp	Angle of Radiation.	Illuminometer Stations										
		0	5	10	15	20	25	26	27	28	29	30
I	13.8—51.3	1.90	2.60	3.65	5.31	7.50	7.88	7.10	5.89	4 24	2.22	....
II	7.1—13.8	0.53	c.63	0.76	0.92	1.15	1.46	1.54	1.63	1.72	1.81	1.90
III	4.8— 7.1	0.24	0.27	0.31	0.35	0.40	0.46	0.47	0.49	0.50	0.52	0.53
IV	3.6— 4.8	0.14	0.15	0.16	0.18	0.20	0.22	0.22	0.23	0.23	0.24	0.24
V	2.9— 3.6	0.09	0.09	0.10	0.11	0.12	0.13	0.13	0.14	0.14	c.14	0.14
VI	2.4— 2.9	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09
VII	....	....	....	....	....	....	....	....	....	....	....	0.06
	Total	2.96	3.80	5.05	6.94	9.45	10.23	9.54	8.47	6.89	5.02	2.06

Table II

case also, in which the relation of the height of lamps over the test surface to the distance of the lamps from each other remains the same as in our example, $7.5:30=1:4$; also where the intensity of the light source is greater, or the lamps hang lower and nearer to each other in the same ratio, the intensity of illumination on the test surface increases at all points by about the same degree, so that the ratio of the intensities at the various points remain the same, and the form of the curves is not changed; the differences in intensities upon the same surface becoming numerically greater, the curves become correspondingly steeper.

Fig. 5 shows that in the case of lamps suspended over the middle of the street, the intensity on a perpendicular test surface increases as a lamp is approached, a maximum being reached possibly 5m. from the lamp, then falling abruptly to the point directly underneath. At the latter point lamp I produces no illumination whatever on the test surface, which is illumined only from the lamp further on. In the case of lamps suspended obliquely to the test surface (Fig. 6) the effect is similar, only the differences are not so great.

In the case of lamps suspended on alternate sides of the street if the test surface is moved beneath either of these rows (Fig. 7), the intensity increases slightly at first, drops somewhat at 30m., because Lamp I ceases to have effect at this point, and reaches a maximum 5m. from lamp II, which is no greater than in the case of Fig. 5, because here the lamps suspended further along the side of the street send their light downward toward the test surface at a less acute angle than in the first case.

As a suitable measure of the variation in illumination, the ratio of the maximum and minimum illumination to the average illumination may be taken; but in this case the average illumination must be obtained by an integration of the entire illuminated surface, as was done by L. Bloch. In another instance Bloch assumes as an average illumination the arithmetical mean between the greatest and least intensity, which is evidently not a proper assumption.

In case the average illumination is un-

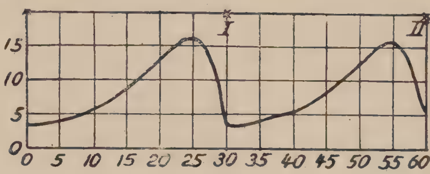


FIG. 5.

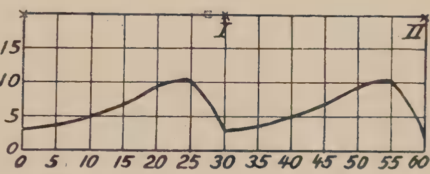


FIG. 6.

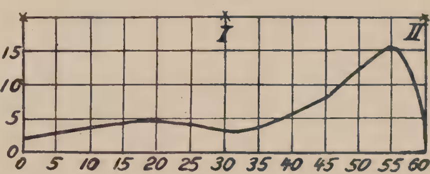


FIG. 7.

known, and the maximum and minimum lie near each other, as can be seen from the curves, so that the inequality is perfectly apparent to the eye, one can assume a ratio of the least to the greatest intensity.

The ratio gives the following measurements:

Lamps over middle of street.

Test line in the center

$$\frac{\max}{\min} = \frac{15.56}{3.10} = 5.02$$

$$\frac{\max}{\min} = \frac{10.23}{2.96} = 3.79$$

Lamps arranged on alternate sides of the street.

$$\frac{\max}{\min} = \frac{10.23}{2.96} = 3.79$$

$$\frac{\max}{\min} = \frac{15.74}{2.55} = 6.17$$

In the latter case, when the greatest inequality appears, it is noticeable that, according to Fig. 7, upon more than half of the surface observed, the uniformity of illumination is by far greater than in the other instances.

These results may now be compared with those obtained by Dreschmidt in Leipziger St., Berlin, whose figures furnished the data for the calculations. The difference in the distance of the lamps from each other (according to Dreschmidt 33m., in this case 30m.) is of no great importance.

First to be noted are the values measured by Dreschmidt for the illumination on a vertical plane on a test line along the middle of the street where the electric lamps are suspended.

Illuminometer Stations.	Intensity on Vertical Plane Above the Middle of Street. Right.	Left.	Mean.
33	1.25	2.05	1.63
22	5.51	3.18	4.34
17	3.47	4.39	3.93
11	2.28	6.81	4.54
0	1.34	1.60	1.47

Table IV

It may be stated here, that Dreschmidt has measured the illumination on the farther side as well as the near side of the street on a perpendicular surface perpendicular to the street, and in the table the two sides are indicated as right and left. But at the same time it is not right to take the average of both of these intensities and to draw conclusions as to the inequality of illumination from such average figures; for only in case of a transparent surface is a value given to the illuminations falling simultaneously upon it from both sides of the street. According to Dreschmidt's comparison of inequality $\left(\frac{\max}{\min}\right)$ on the right 4.41, left 3.18 and on average of 2.72, also in the average values less than right and left. The Dreschmidt figures must be placed as much nearer each other as given in the following table, where they show the variation of the intensity in the direction toward either end of the street. Theoretically, both of these rows should be the same; if they are not, then it must be inferred that the lamps burning in the one direction from the test surface have a different intensity, at the moment of measurement from the intensity of those in the opposite direction; from which it is evident that the intensity is derived from the nearest lamps in both directions.

From the less intensity measured by Dreschmidt, in comparison with the intensities which I measured, it must be assumed that the intensity of the electric arc enclosed in translucent glass burning in Leipziger street is only half as great as I have assumed according to my estimate, and therefore is equal to only 1000 Hefner candles.

In comparing the Dreschmidt figures with those I obtained, the difficulty presents itself at once that the Dreschmidt figures for the positions O and 33 are not the same, as they should be theoretically, and on account of the difference in intensity of the various lamps, the comparison is impractical. Nothing remained but to compare with each other the amounts of the five intensities in both cases, from which the reduction factor 2.01 was obtained, and by using that in the Dreschmidt observations the figures given in the last column were obtained. If these are compared with fig-

Lamps 6m from the Middle (alternately to the right anh left), Test Surface 6m from the Middle.

Lamp	Angle of Radiation	Illuminometer Stations 0	5	10	15	20	25	26	27	28	29	30
I	13.1—32.0	1.45	1.78	2.16	2.49	2.50	1.70	1.42	1.10	0.74	0.38	....
II	7.1—90	0.54	0.64	0.77	0.95	1.19	1.56	1.61	1.70	1.80	1.91	2.03
III	4.7—13.1	0.23	0.26	0.29	.33	0.37	0.43	0.44	0.45	0.47	0.48	0.49
IV	3.6— 7.1	0.14	0.15	0.16	0.18	0.20	0.22	0.23	0.23	0.23	0.24	0.24
V	2.9— 4.7	0.09	0.09	0.10	0.11	0.12	0.14	0.14	0.14	0.15	0.15	0.15
VI	2.4— 3.6	0.06	0.07	0.07	0.07	0.08	0.09	0.09	0.09	0.09	0.09	0.09
VII	3.0— 2.9	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
VIII	....	....	....	....	....	....	....	....	....	....	....	0.04
	....	....	....	....	....	....	....	....	....	....	....	....
	Total	2.55	3.04	3.58	4.18	4.51	4.20	3.98	3.77	3.54	3.31	3.10

Lamp	Angle of Radiation	Illuminometer Stations 35	40	45	50	55	56	57	58	59	60
I	13.1—32.0	....	....	....	....	....	....	....	....	....	....
II	7.1—90	2.81	4.10	6.36	10.24	13.66	13.03	11.39	8.55	4.75	....
III	4.7—13.1	0.57	0.67	0.80	0.96	1.18	1.22	1.27	1.33	1.38	1.45
IV	3.6— 7.1	0.27	0.31	0.35	0.40	0.46	0.48	0.49	0.51	0.53	0.54
V	2.9— 4.7	0.16	0.18	0.19	0.21	0.22	0.22	0.22	0.22	0.22	0.23
VI	2.4— 3.6	0.10	0.10	0.11	0.12	0.13	0.14	0.14	0.14	0.14	0.14
VII	3.0— 2.9	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09
VIII	....	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
	....	....	....	....	....	....	....	....	....	....	0.04
	Total	4.03	5.48	7.94	12.06	15.80	15.24	13.57	10.90	7.15	2.55

Table III

INTENSITY ON VERTICAL PLANE ABOVE MIDDLE OF STREET.

Illuminometer Stations. Dreschmidt	Kruss	Dreschmidt's Measurements. Right.	Left.	Mean.	Kruss' Estimates.	Dreschmidt's Corrected.
0	0	1.34	2.05	1.69	3.10	3.39
11	10	2.28	3.18	2.73	5.51	5.48
17	15	3.47	4.39	3.93	8.02	7.89
22	29	5.51	6.80	6.16	12.23	12.35
33	30	1.25	1.60	1.42	3.10	2.85
				15.93	31.96	31.96

TABLE V

ures given in the next to the last column, both will be found to correspond exactly. From this it must be concluded that the estimated distribution of illumination from the electric arcs in the various directions in Liepziger street, whose efficiency Dreschmidt has measured, was really a matter of fact, and also that the inequality of the electric arc was entirely balanced by the translucent globe used with it. If the globes are not too transparent, that is not impossible, and occurs, just as in the Kugel photometer, through the manifold reflections from the inner surface of the globe.

Since Dreschmidt's observations commenced 11m. from the point directly under the lamps, he has missed the maximum intensity of the vertical surface for comparison, as it lies about 5m. from this point.

In the same manner Dreschmidt's measurements along the curb have been placed side by side in the following table with the intensities I obtained.

The simplest arrangement seems to be the suspension of the lamps over the middle of the street with the test surface also over the middle. Table I shows that in this case lamp I has the most efficient angle of radiation at an angle of 76 degrees, while that of the more distant lamps, II to VI, varies from 2.4 to 14 degrees. Of these lamps (II to VI) lamp II furnishes the greatest quantity of illumination, so that any change in the light it gives out would have an effect upon the general result. A decrease in the effect of lamp II would seem, however, not very probable if its effect in the positions near lamp I (at 29) is considered. An increase is, however, equally irrational, since the effect of lamp I must be then diminished more than is reasonable. It therefore seems logical that the proportion of radiation between zero and 14°, and also the effect of lamps II to VI, should remain unchanged, i. e., the correction should be applied equally to all directions within the angles from 14° to 90°, within which lamp I effects the measuring surface.

The problem now remains to determine to what intensity the correction shall be applied, whether the maximum, minimum, or the average illumination. The maximum would seem to be excluded because the form of the distribution curve is unnatural. In the following comparison therefore the correction is supplied only to the minimum. In this respect it must be particularly noticed that the resulting intensity, 3.01, signifies only that this intensity arises when the lamps are 2000 c.-p. in a horizontal direction, and their curves of distribution correspond to the figures given. By the simple increase or decrease of the intensity of the light-sources, the resulting intensity is varied proportionately. This curve is shown in Fig. 8, which indicates that the

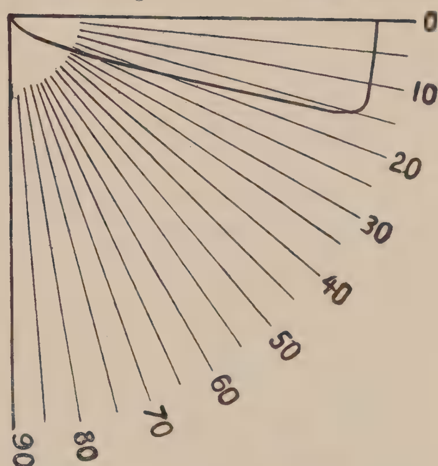


FIG. 8.

INTENSITY ON VERTICAL PLANE AT THE CURB.

Illuminometer Stations. Dreschmidt.	Kruss.	Dreschmidt's Measurements. Right.	Left.	Mean.	Kruss Estimates.	Dreschmidt's Corrected.
0	0	1.52	2.28	1.90	2.96	3.52
11	10	2.02	3.00	2.51	3.80	4.65
17	15	2.88	3.17	3.27	6.94	6.06
22	20	4.96	5.08	5.02	9.45	9.30
33	30	1.14	1.64	1.39	2.96	2.58
				14.09	26.11	26.11

TABLE VI.

lamps must radiate as little light as possible below the horizontal, and also that the light sources have an exactly opposite distribution from the flaming arc lamp, which, as has been admitted, gives an unequal illumination. The use of reflectors must also be avoided, since they direct the upward light directly downward. In order to utilize this upward light, it must be directed by special reflectors which cause the light to radiate horizontally. A light-source having the theoretical curve is difficult to construct, at least if it is to work with efficiency. An electric arc provided with a globe having Fresnel lenses, which, as in electric light houses, usually reflects a large part of the light almost horizontally, might be used.

It will be seen that Dreschmidt's curve of radiation of the Welsbach light comes nearer to being the ideal curve than that of the electric arc, since in the Welsbach light the maximum radiation is in the horizontal direction. On this account, Dreschmidt secured a far greater uniformity of illumination on the vertical plane in the light of Frederick street, where Lukas lamps were used, than in Leipziger street, which is lighted by electric arcs. The newer forms of Lukas lamps, the distribution of which has been recently described by Wedding, approach very nearly the theoretical curve.

The comparisons given in tables VIII and IX show the intensity on the vertical plane between the lamps when the theoretical curve obtained from the first arrangement (lamps and test surface above the middle of the street) is used. In both of these arrangements the ideal curve shows a very uniform distribution on the vertical plane, as might be expected, since the character of these curves is very similar.

The numerical value of the calculations applies to the figures given, and particularly to the ratio of the height of the lamp above the measuring surface to the distance between the lamps (in this case I to IV) determining the angle of incidence. It is hardly necessary to calculate the values for other angles of incidence, since data can be obtained from the foregoing figures to determine the nature of the curves in such cases. If the lamps hang lower, and at the same distance from one another, the illumination is less uniform, since the angle of

LAMPS ABOVE THE MIDDLE OF THE STREET. TEST SURFACE ABOVE THE MIDDLE OF THE STREET.

Station of Test Surface.	0	5	10	15	20	25
Angle of radiation of Lamp I	14.0	16.7	20.6	26.6	36.9	56.3
Illumination by Lamp I	2.03	2.81	4.10	6.36	10.24	13.66
Reduction Factor	1.00	0.67	0.41	0.23	0.11	0.05
Reduced Illumination by Lamp I	2.03	1.88	1.69	1.44	1.11	0.64
Illumination by Lamps II–VI	1.17	1.22	1.41	1.66	1.99	2.46
Total Illumination	3.20	3.10	3.10	3.10	3.10	3.10

TABLE VII.

LAMPS ABOVE THE MIDDLE OF THE STREET, TEST SURFACE 6M FROM MIDDLE,
OR
LAMPS 6M FROM MIDDLE, TEST SURFACE ABOVE MIDDLE OF STREET.

	0	5	10	15	20	25
Angle of Radiation of Lamp I	13.8	16.3	19.8	34.9	32.7	43.8
Illumination by Lamp I	1.90	2.60	3.65	5.31	7.50	7.88
Reduction Factor	1.00	0.66	0.56	0.28	0.15	0.08
Reduced Illumination by Lamp I	1.90	1.72	2.04	1.49	1.12	0.62
Illumination by Lamps II–VI	1.06	1.20	1.40	1.63	1.95	2.35
Total Illumination	2.96	2.92	3.44	3.12	3.07	2.97

TABLE VIII.

LAMPS 6M FROM MIDDLE (RIGHT AND LEFT). TEST SURFACE 6M FROM MIDDLE.

Station of Test Surface.	0	5	10	15	20	25	30	35	40	45	50	55
Angle of Radiation of Lamp I	13.1	15.1	17.8	21.1	25.4	30.6	.....	.....	.....	.....	.....	.....
Illumination by Lamp I	1.45	1.78	2.16	2.49	2.50	1.70						
Reduction Factor	1.00	0.78	0.60	0.39	0.28	0.17	.....	.....	.....	.....	.....	.....
Angle of radiation of Lamp II	7.1	7.8	8.2	9.5	10.6	12.1	14.0	16.7	..... 20.6	..... 26.6	..... 36.9	..... 56.3
Illumination by Lamp II	0.54	0.64	0.77	0.95	1.19	1.56	2.03	2.81	4.10	6.36	10.24	13.66
Reduction Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.67	0.41	0.23	0.10	0.05
Reduced Illumination of Lamp I	1.45	1.39	1.30	0.97	0.70	0.29	.....	.....	.....	.....	.....	....
Reduced Illumination of Lamp II'	0.54	0.64	0.77	0.95	1.19	1.56	2.03	1.88	1.68	1.46	1.02	0.68
Illumination by Lamps III–VII	0.56	0.62	0.65	0.74	0.82	0.94	0.97	1.22	1.38	1.58	1.82	2.14
Total Illumination	2.55	2.65	2.72	2.66	2.71	2.79	3.10	3.10	3.06	3.04	2.84	2.82

TABLE IX.

incidence becomes greater in all positions on the vertical surface, and the intensity consequently increases. The decrease in effect produced by the increase in the angle of incidence is offset by the increase in effect produced by the approach of the test surface to the light source. The less the compensation, the greater will be the inequality of illumination.

I did not determine the intensity on the horizontal plane for the various positions, not only because I consider these less important, but principally not to weary with a further accumulation of figures which the reader can easily make for himself. The pleasant opportunity has been afforded of showing that the calculation of these values explains many results of observation, which is the principal reason for the foregoing discussion.

THE DACH PHOTOMETER

By L. Weber.

From *Zeitschrift für Beleuchtungswesen,* October 30.

In the article on the present status of the Photometer, by A. C. Jolley, in a former issue of the *Zeitschrift für Beleuchtungswesen,* a simple photometrical apparatus called the "Trotter Photometer" was described. I described this same instrument myself at an earlier date, and called it the "Dach Photometer." As far as I recall, I made my first announcement concerning it at the meeing of the National Science Association, at Schleswig-Holstein, April 10, 1893, and have since given a complete description in "The Hand Book on Hygiene," by Th. Weyl (Vol. 4, part 1, page 52), under the title of "Illumination." The only difference between my instrument and the Trotter Photometer, which is shown therein, is that I have chosen a square screen spot, while in the Trotter a star shaped one is used. In the latter case it is impossible to perceive any improvement, since it is much more difficult to cut the star shaped opening in the cardboard smooth enough so that the surface cut will not present a line disturbing to the eye.

Until 1887 the Bunsen Photometer took the lead as being the most sensitive of all the photometers depending upon the simple law of distance, and was adapted for most practical purposes. This superiority depended upon the fact that both surfaces, whose equal intensity of illumination was to be determined by the eye, were contiguous, so that the circle in the center was such that there was no noticeable line of separation made by the outer surface and both being of equal intensity to the eye, appear as one uniformly illuminated surface.

A second advantage was that the light-sources to be compared were on opposite sides of the photometer. By this means it was possible to adjust the instrument exactly, to leave light-sources sensitive to jarring undisturbed, and to make the measurement by a single setting.

The complete theory of the Bunsen Photometer, as stated by me then, showed that in the visible difference of intensity it was only ⅓ as sensitive as other photometers in which but one light source illuminated a single surface of the two to be compared. On the Bunsen screen, various kinds of paper being tried, the transmitted light and reflected light mingle in a manner highly detrimental to sensitiveness. The theory showed that to remove this prime objection a screen must be used of absolutely white, opaque cardboard, capable at the same time of rendering the grease-spot perfectly transparent. To fulfill both of these conditions was manifestly impossible. At this point a clever scheme, worked out by Messrs. Lummer & Brodhun, of inserting two similar surfaces illuminated by the light sources, and viewing these through their highly ingenious arrangement of prisms, removed this difficulty. The center of the prism is perfectly transparent to one light-source, and the part around the center reflects the light equally well without confusing the reflected rays, and without losing the advantages of the Bunsen Photometer, namely, the contiguity of surfaces to be equally illuminated, and the position of the screen being on a direct line between the light sources. By means of this device the Bunsen Photometer was improved three-fold, and the Lummer-Brodhun instrument quickly supplanted the old Bunsen form by its very simplicity. Every theoretical requirement is fulfilled in the principle of my little Dach Photometer, in that the spot (in this case the opening) has obsolute transparency, and the surrounding cardboard is opaque, while each surface examined is illuminated from the one light-source. For these reasons the Dach Photometer gives the simplest solution of every theoretical demand, and therefore a return to the use of the sharply cut and acute angle screen spot seems highly improbable.

THE TECHNICAL PECULIARITIES OF THE INVERTED INCANDESCENT GAS BURNER

By H. Sussman.

From *Journal für Gasbeleuchtung,* Munich, Sept. 22, 1906.

Lamp makers have endeavored for many years to make an incandescent gas burner comparable in its decorative effect to the

pleasing form of the incandescent electric lamp, and also to increase the efficiency of illumination at the same time. They have sought to attain both of these objects by inverting the incandescent gas burner so as to give the maximum intensity in the lower hemisphere.

There can be no doubt that in cases where intensity in the lower hemisphere is necessary such an inverted burner has an advantage over the upright Welsbach, in which the light can be directed below only by means of a reflector, and that with a loss; but on the other hand, where it is desirable to illuminate the entire room, as in the case of living rooms, in order to display the mural and other decorations, the old time upright burner will never be supplanted by the inverted.

Now, after the importation of the inverted burner has increased as greatly as it has during the past three years, and having created universal interest, the question is being seriously raised by various authorities and governments as to its suitability for street illumination.

Already a large number of inverted burners of various construction have appeared on the market, and disappeared again, and still every day new forms are being introduced.

In the patents on inverted burners two diametrically opposed principles have been followed. In the one case the object is to keep the mixture of air, as in the Bunsen burner as cool as possible; in the other, to heat the mixture as much as possible on the assumption that this pre-heating produces an increase in light and a consequent economy of gas.

It is evident that in the case of the inverted Bunsen burner, in which, contrary to the upright burner, the flame burns below the nozzle and mixing tube, the gas burning upwards, according to nature, the different parts of the fixture are heated greatly, as well as the gas and air circulating in the tube. There is also no doubt that any heating of the gas before burning must give an increase of energy and an increase of flame temperature, unless other forces are set in action at the same time which offset the increase of energy gained by heating.

If the mixing tube of an upright Welsbach burner be heated, the upward flow of gas should be increased on account of the increase in pressure due to the heating, and the increased velocity thus produced should be followed by a corresponding increased suction of air; at least this would seem to be a natural supposition. Experiment, however, shows the contrary to be the case. If the mixing tube of a Welsbach burner, which has been carefully adjusted and shows the characteristic short green inner flame just above the burner, be heated by means of another Bunsen burner, it will be noticed that, as the heating proceeds, the green inner flame lengthens and its color becomes more like the surrounding flame, until finally a luminous flame is produced similar to that of an Argand burner.

The lower the gas pressure supplied to the burner, the lower the temperature of combustion. This phenomena is found not only in the Welsbach burner, but an experiment with the ordinary Bunsen burner shows the same fact. If a Bunsen burner is inverted, and the products of combustion kept from entering the air-holes of the burner by a suitable arrangement, the burner tube will become highly heated, not only by the heat conducted from the flame, but to a greater extent by the rising stream of highly heated gases.

By inverting the burner the direction of the flow of gas is likewise inverted; but the force of the upward pressure will not be thus changed, so that in the inverted burner, contrary to the case in the upright, the upward pressure acts as a retarding force, which increases with the rise in temperature. This phenomenon may be observed by heating an upright burner, but is much more apparent in the inverted burner. If the ordinary laboratory Bunsen burner be inverted and jacketed so as to prevent the combustion gases from entering the air holes, it will be noticed that at first, so long as it is cold, it continues to burn with the normal Bunsen flame; but that as it becomes hot the Bunsen flame grows fainter, and finally a luminous flame is produced. If the intensely heated burner is now returned to its original position the flame will continue to burn in a normal manner from the moment of lighting. The rate of the flow of gas through the nozzle is retarded to such an extent by the back pressure due to heating that not enough suction is produced to provide the requisite amount of air. If such inverted burner is fitted with a mantle, and the burner tube surrounded with a water jacket in which water is kept circulating, it will be seen that so long as the tube is kept cool the flame does not change its normal condition.

These experiments show that, along with the positive increase of energy due to the heating of the gases, a counterbalancing force is produced which retards the flow of gas, as is apparent by the change in the air suction produced. Thus, while increased energy is obtained by the pre-heating process on the one hand, it is also counteracted, and if the loss exceeds the gain the pre-heating process gives a corresponding negative result.

These experiments show that pre-heating the gases in the inverted burner does not, in all cases, signifv an increase in efficiency. Since the temperature of the Bunsen flame increases with the quantity of air used, and

since inverting it decreases the air suction, it follows beyond a doubt that in the case of the inverted burner the temperature of the flame is increased by the pre-heating process, but that this in turn is lost on account of the decrease in the supply of oxygen. Pre-heating therefore affords a limited gain, if any.

In the practical use of the inverted burner only two conditions need be considered. At the moment of ignition the burner is cold, and therefore has a greater air suction than later, when it begins to heat up. The quantity of air requisite to the practical operation of the burner must be regulated first of all so that when cold there is no greater air suction than is necessary in order to avoid the flame striking back; since in proportion as the tube becomes heated, the air suction diminishes and the combustion becomes incomplete. It is noticeable in such a burner if it be used without the mantle, that shortly after lighting the flame exhibits the characteristic green inner cone of the correct Bunsen type, and this green inner flame gradually fades and lengthens. If the air-holes are provided with a sliding ring for adjustment, so that more air can be admitted after it becomes hot, the light will be increased. On account of this, if it is necessary to again light such a burner after it has cooled, the air holes must first be closed, as otherwise it is difficult to light it. Such manipulation of a burner, however, entirely excludes it from practical use.

In the laboratory, however, this method is often used to determine the extent to which the pre-heating of the gases in the inverted burner is of advantage in the production of light.

Many inventors who make their own burners regulate them while in operation in the manner described. In all such burners, in which the regulation has been adjusted while hot, I have extinguished the burner and allowed it to cool before relighting it, in which case it was plainly shown that re-lighting was impossible, as the flame struck back, so that the air holes had to be first closed up. When efforts were made to regulate the burner, so that it would be unnecessary to adjust it after lighting, and in consequence the illumination did not meet expectations, the inventors were always convinced of their error. This explanation clearly indicates that the high efficiency which inverted burners have shown by laboratory measurement are frequently not obtained in practise. I am of the opinion that laboratory results are not wholly reliable, and that the results of practical use must be determined as well.

From these observations it would seem that the best inverted burner would be the one in which its condition changes least from that which it has at the moment of lighting. Accordingly that construction will be best and most practical in which not the greatest amount of pre-heating is aimed at, but an approach to the two different conditions that maintain at the time of ignition and after continued burning, and in which the air suction is not affected by the condition of temperature. Over-heating of the burner tube is undesirable, since, being made of brass it becomes brittle after continued heating and soon falls to pieces. In such burners it will be noticed that dark scales produced by oxidization of the metal fall on the glass globes used. The sulphur present in illuminating gas has its full share in this result. Upon these purely practical grounds it is recommended that the burner tube be protected from the effect of all hot gases.

It is also to be noted that inverted burners in which the gas is pre-heated to any considerable extent are not suitable for use on the lower gas pressures. Not only experience, but a little consideration of the theory will show this to be true. The energy of the air suction is the difference between the energy of the gas issuing from the nozzle, and the counteracting back pressure. This is mathematically expressed by the equation $L = E - A$, in which L indicates the energy of the air suction, E the energy of the gas at the nozzle, and A the back pressure. The greater A becomes in proportion to E in this equation, the less L becomes. The energy of the gas at the nozzle varies as the square of its velocity. The equation is:

$$E = \frac{MV^2}{2}$$

If, for example, the gas pressure falls from 4 to 3 mm., or about 25%, the velocity is decreased to 85%, and the energy to 20.5% of the original. The force of the back pressure varies as the mass, and also with the velocity, i. e., with the square root of the gas pressure; it is therefore 85% of the original back pressure. While the energy of gas flow in the assumed example is changed a little more than 80%, the force of the back pressure is only about 14%. From this it follows that the greater the back pressure, the less will be the difference in the downward pressure between these forces, which represents the force of the air suction.

The following example will make this clear: Let the energy of the flow of gas, E. = 10, and the energy of the back pressure A, = 1, then the actual working energy E—A=9. In the decrease of gas pressure from 40 to 30 mm., as above cited, or about 25%, E falls to 2.05, and A to .86; therefore in this case E—A=2.05—.86 = 1.19.

If the back pressure increases from 1.0 to 1.5 on account of heating, as, for ex-

ample, to a temperature of 150°, which may happen, then the force of the gas flow E—A=2.05—1.5=.55 of the original force. While the remaining energy of gas flow is reduced from 2.05 to 1.19, or about 42%, when the burner is cold, it is decreased more than 73% when raised to a high temperature. From this it follows that when raised to a high temperature, and the back pressure is consequently increased, the gas pressure needs to be decreased but little to render the inverted burner a complete failure. A practical test confirms this statement. Over-heating is, therefore, not only unnecessary, but greatly endangers the practical utility of the inverted burner.

Now, as it is impossible to keep an inverted burner alwavs cool, since it has been shown that cooling with water is impractical, keeping it as cool as possibly by some suitable arrangement must suffice. This may be most readily accomplished by keeping the products of combustion at a distance from the burner tube, by diverting them from the point where they are generated, and by endeavoring to prevent the conduction of heat by the use of proper insulators.

In order to obtain a balance of air suction at the burner in both its hot and cold states, which can never be fully accomplished, an arrangement suggests itself for the automatic regulation of suction. Such a device is found in a piece of wire gauze placed in the expanded part of the mixing tube. The operation of this device depends upon the well-known law that the resistance which a surface presents to a current of gas or air in motion is proportionate to the specific gravity of the medium in motion. The wire gauze presents a perforated surface, the obstructing parts of which offer a known resistance to the current of gas and air.

If the current of mixed gases becomes heated on passing through the heated tube, its specific gravity will be diminished and the resistance of the wire gauze decreased. By a suitable selection of gauze, and by raising the gas and air mixture to a certain temperature. this variation will have the same ratio as the decrease in resistance of the gauze bears to the increase in the back pressure cause by heating. By this simple means it is possible to obtain a balance, at least within certain limits.

It has already been mentioned that it is impossible to keep the inverted burner perfectly cold. This is the reason why the normal dimensions of the Bunsen burner cannot be supplied to the inverted burner. According to the well-known empirical rule, the diameter of the mixing tube in the Bunsen burner should have a cross section 75 times as great as the cross section of the nozzle opening. This rule is based upon the fact that, under ordinary conditions of pressure, the velocity of gas at the nozzle amounts to about 25M, and of the gas and air mixture at the burner head to about 1M, and that the gas must mix with three times its quantity of air. In the inverted burner the gas and air increase in volume on account of heating, which must be taken into consideration. On this account inverted burners do not have the dimensions which they would have according to this rule, the burner tube having a considerably larger cross section. The heating of the gas and air mixture takes place on the way to the burner-head. The tube must therefore be constructed accordingly at the mixer, and must widen toward the burner to allow for the expansion of the gases. The important fact follows that a burner tube of uniform dimensions is of great advantage, and that the burner is sensitive to sound waves. By means of this arrangement the greatest possible quantity of air is mixed with the gas.

It is well known that the motion of gases is transmitted only to a certain extent; the current of gas issuing from the nozzle will set the air about it in motion only within a certain radius. The particles of moving air produce friction among the adjacent particles in transmitting their motion. Now, since the friction of a stratum of gas or air is greater against another stratum at rest, or moving more slowly, than against the surface of a solid body, it is evident that a greater loss of energy by friction will be produced in a burner tube of too great diameter than in a narrower one, in which the only friction encountered by the moving column of air is from the walls of the tube. It is, therefore, apparent that the dimensions of the mixing tube of a burner must be kept within certain limits. Experiments show that when the Bunsen tube of an upright Welsbach burner is widened beyond the usual size the Bunsen flame and the illumination are not improved, but are rather impaired. The same applies to the inverted Bunsen burner. For this reason it must follow that the tube of an inverted burner should begin with a dimension of cross section determined by experience, and must widen at the head in accordance with the expansion of the heated gas. This construction until recently was unusual, having received little or no attention at first, but has lately come largely into use.

Besides these principles, based on physical laws, still more weighty considerations arise from the actual construction and use of such burners. The regulation, that is, the adjustment of the size of the nozzle holes to the variations in gas pressure, is usually accomplished in the upright Welsbach burner by enlarging the nozzle opening with a reamer, or closing it up with a punch. Such regulation is not only neces-

sary in each new installation, but also when an old mantle is replaced with a new one, since mantles are not always of the same size, and consequently vary somewhat in shape, so that the web would not lie in the hottest portion of the flame. The accurate regulation by reaming or punching the fine nozzle holes takes considerable time, and can be done only by a workman equipped with the necessary tools. It is, therefore, necessary to construct a regulating nozzle which will not only displace the use of the reamer and punch in some simple manner, but also make it possible for the user to adjust the burner so as to obtain the maximum illumination from the gas used after replacing the mantle, or when there is occasional increase of pressure. A regulating nozzle is essential in the inverted burner also because the burner parts become highly heated, and hence require a long time to cool after turning off; and it is often necessarv to light them several times before the right adjustment of gas is obtained. This regulation of the nozzle in the case of the inverted burner is a very delicate operation, as it is also in the upright burner, and because of the great care necessary there is no doubt that a regulating nozzle for this type of burner is very important.

In a good regulating nozzle the flow of gas should not be obstructed at the opening, as an obstruction to the flow of gas between the inlet and the nozzle opening reduces the pressure, which in turn diminishes the energy of the gas jet, so that it does not draw in the necessary amount of air into the mixing tube. In order that the gas may be adjusted to give full pressure at the nozzle opening it must be so constructed that the opening may be varied according to the flow of gas without diminishing the pressure. This is possible only with a nozzle having a plate, as in the ordinary 5-hole nozzle, since the friction is then reduced to the least possible extent in the short space corresponding to the thickness of the plate, which in this case is small. Moreover, an opening in a thin plate has the advantage of lessening the sound of flowing gas.

The inverted incandescent gas burner has recently come into use for exterior illumination also; and for this purpose it has been used either singly, or grouped in a fixture. In the consideration of lamps designed for exterior illumination the same principles are desirable as in the ordinary inverted burner, viz.

1. The products of combustion must be kept at a distance from the burner tube.

2. The burner tube should have a special widening at the burner-head.

3. A wire gauze should be placed in the mixing tube.

4. The burners must be readily adjustable by a regulating nozzle.

5. A special soot receptacle must be provided to protect the nozzle.

It is evident that such a fixture must also be proof against rain and water.

Experience has also shown that it is no small advantage in a lamp to have the inner parts accessible so that they can be readily changed, so that after long use the burner tube may be freed from the dust accumulation that is drawn into it without the necessity of removing the lamp from its support. It is of equal advantage to be able to remove the burner tubes easily without having to take the lamp apart.

Heretofore lamps for exterior illumination have been lighted by means of pilot flames. These pilot flames are permanently fixed above the mantle in the chamber through which the combustible gases are conducted. This arrangement is objectionable because the small flame, receiving insufficient oxygen, invariably becomes sooty. For this reason the pilot flame should not be placed within the combustion chamber proper, nor in the supply tube. In a recent construction the pilot flame is placed over the partition between the combustion chamber proper and the air chamber holding the burner tube. In this case there is a small opening in the partition below the pilot flame through which ignition takes place. The suction of the chimney draws up the gas of this pilot flame and ensures its receiving a sufficient amount of air, and also that the gas emanating from it shall not affect the burner. The lighting of lamps without the aid of the pilot flame has been unknown until recently, and there are indeed some difficulties attending even the improved method. For instance, if an attempt is made to light the lamp through the chimney a serious explosion results, which may easily destroy the entire lamp.

We see that this field offers a wide territory for inventive genius, but only those inventors will obtain practical results who are not led by the momentary caprice of imagination, but who take advantage of their knowledge of the peculiarities of the inverted burner and who practically apply the knowledge thereby obtained. The points that I have presented may afford some suggestions for the construction of inverted burners, and may be helpful in distinguishing the useful from the useless, and so guard against discouraging experiments.

Commercial Engineering of Illumination

MEETING PROVISIONAL ORGANIZATION COMMITTEE OF THE CO-OPERATIVE ELECTRICAL DEVELOPEMENT ASSOCIATION

Last March, it may be remembered, a joint meeting of a number of leading men from all branches of the electrical trade was held in New York. At this meeting a very representative committee was appointed to co-operate in developing the plans and in perfecting the organization.

Mr. W. M. McFarland, acting vice-president of the Westinghouse Electric & Manufacturing Company, chairman of this committee, called a meeting for Dec. 13th, 1906, at the Imperial Hotel, New York, to further consider the objects, plans, results and organization of the association.

At the morning session Mr. J. Robert Crouse presented a paper dealing with the work and results, which was fully discussed.

This was followed by a further paper on the commercial plans formulated for the future, which was likewise discussed from various points of view.

At 1.30 P. M. the gentlemen present lunched together, and at 3.00 P. M. assembled for the afternoon session.

The first part of the session was devoted to a reading of the proposed Constitution and By-Laws, after which a general and lively discussion of the entire proposition was indulged in.

The sense of the meeting was crystallized in the following resolution, introduced by Mr. Walter Cary, of the Sawyer-Man Electric Company, which was unanimously passed:

"RESOLVED—That it is the sense of this meeting that the commercial programme untlined for the Co-Operative Electrical Development Association for 1907 and the future is along sound lines, and gives good promise of highly profitable returns to all concerned.

"It is the further sense of this meeting that immediate steps be taken to perfect the organization of the association and to prosecute its commercial plan vigorously, pursuant to which the chair is requested to appoint three committees, of five members each as follows:

"Committee on Constitution and By-Laws.

"Committee on Membership Assessments.

"Committee on Commercial Programme."

The Chair appointed the following Committees:

COMMITTEE ON CONSTITUTION AND BY-LAWS.

Mr. E. E. Jackson, Chairman.

Mr. A. D. Page, General Electric Company.

Mr. Walter Cary, Sawyer-Man Electric Company.

Mr. F. J. Newbury, John A. Roebling's Sons Co.

Mr. W. W. Freeman, Edison Electric Illuminating Co., of Brooklyn.

COMMITTEE ON COMERCIAL PROGRAMME.

Mr. F. S. Terry, Chairman.

Mr. W. C. Bryant, Bryant Electric Company.

Mr. R. S. Hale, Edison Electric Illuminating Co.

Mr. A. L. Doremus, Crocker-Wheeler Co.

Mr. W. F. Gillmer, Peerless Electric Company.

Mr. F. Bissell, The F. Bissell Company.

COMMITTEE ON MEMBERSHIP AND ASSESSMENTS.

Mr. J. S. Anthony, Chairman.

Mr. Walter Cary, Westinghouse Electric and Mfg. Co.

Mr. W. W. Freeman, Edison Electric Ill. Co., of Brooklyn.

Mr. Charles B. Price, Pettingell-Andrews Co.

Mr. James R. Strong, Pres. National Electrical Contractors Association.

These committees will, in the immediate future, formulate and submit their detailed report to the Chairman of the Joint Committee, so that at its next meeting the Co-Operative Electrical Development Association may be formally and finally launched.

In the evening at 8.00, the confreres sat down to a banquet, over which Mr. J. S. Anthony, of the General Electric Company, presided gracefully.

The more serious business of the day having been dispatched, the evening was given over to the cultivation of closer acquaintance and general good-fellowship.

The following is a list of those in attendance:

Mr. W. W. McFarland, Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Mr. Walter Cary, Sawyer-Man Electric Co., New York, N. Y.

Mr. W. C. Bryant, Bryant Electric Co., Bridgeport, Conn.

Mr. J. S. Anthony, General Electric Co., New York, N. Y.

Mr. A. D. Page, General Electric Co., Harrison, N. J.

Mr. E. S. Keefer, Western Electric Co., New York, N. Y.

Mr. A. L. Doremus, Mr. Rodman Gilder, Crocker-Wheeler Co., Ampere, N. J.

Mr. E. W. Goldschmidt, Wagner Electric Mfg. Co., St. Louis, Mo.

Mr. F. S. Terry, National Electric Lamp Co., Cleveland, Ohio.

Mr. F. J. Newbury, John A. Roebling's Sons Co., Trenton, N. J.

Mr. E. E. Jackson, New York, N. Y.

Mr. W. H. Blood, Stone & Webster, Boston, Mass.

Mr. W. W. Freeman, Edison Electric Illuminating Co. of Brooklyn, Brooklyn, N. Y.

Mr. Jno. F. Gilchrist, Chicago Edison Co., Chicago, Ills.

Mr. R. S. Hale, Edison Electric Illuminating Co., Boston, Mass.

Mr. J. E. Montague, Buffalo & Niagara Falls El. Lt. & Pr. Co., Niagara Falls, N. Y.

Mr. F. M. Tait, Dayton Lighting Co., Dayton, Ohio.

Mr. F. Bissell, The F. Bissell Co., Toledo, Ohio.

Mr. Chas. B. Price, Pettingell-Andrews Co., Boston, Mass.

Mr. James R. Strong, Pres. National Electrical Contractors' Association, New York, N. Y.

The following gentlemen who were expected to be in attendance were unable to be present:

Mr. Arthur Williams, Pres. National Electric Light Association, New York, N. Y.

Mr. Henry L. Doherty, New York, N. Y.

Mr. Gerard Swope, Western Electric Co., Chicago, Ills.

Mr. C. A. Stranahan, Allis-Chalmers Co., Milwaukee, Wis.

Mr. A. T. Clarke, American Circular Loom Co., Chelsea, Mass.

Mr. N. W. Rockefellow, Western Electric Co., New York, N. Y.

$2,600, IN PRIZES FOR AN ELECTRICAL SOLICITOR'S HANDBOOK

Earlier in the year, as will be recalled, the Co-Operative Electrical Development Association offered $1,000 in prizes for papers on the subject of the organization and conduct of new business departments suitable for central stations in cities of fifty thousand population and under. These prizes were awarded by the President of the National Electric Light Association at the Atlantic City Meeting on the judgment of a special committee, since which time they have been given very wide publicity through the co-operation of the electrical technical press, as well as iussues by the association in pamphlet form.

A few weeks since the subject of offering prizes for an Electrical Solicitor's Handbook was discussed with the Co-operating Committee of the National Electric Light Association, and it was decided to offer $2,600 in prizes for such a production. The prize money is divided as follows:

$1,000 for the Light Section, of which $500 will be awarded as the first prize; $300 as the second and $200 as the third.

$1,000 for the Power Section, of which $500 will be awarded as the first prize; $300 as the second and $200 as the third.

$600 for the Heat Section, of which $300 will be awarded as the first prize; $200 as the second and $100 as the third.

In general it is desired to secure a handbook which will be both instructive and stimulating to representatives of central stations, contractors or others who are soliciting the public for the sale of electrical service for light, heat and power.

A little pamphlet is in the course of preparation containing general suggestions for the benefit of those who will compete for the prizes, and this will be very gladly sent upon request.

A committee appointed by the president of the National Electric Light Association will judge the hand-books, or sections of the handbooks, submitted, and their decision, which will be made just before the next meeting of the National Electric Light Association, will be announced at that convention, and the nine New York drafts for the several amounts distributed to the winners.

The winning contributions, or combination of winning contributions, will be made of the greatest possible benefit to the electrical business, along such lines as may be later determined by the Joint Committee.

This affords an excellent opportunity to make a valuable contribution to the commercial progress of the art, to achieve a reputation for business progress, and withal, to be well paid for the time, thought and energy required.

STANDARD SYMBOLS FOR WIRING PLANS

AS ADOPTED AND RECOMMENDED BY

THE NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION OF THE UNITED STATES.

COPIES MAY BE HAD ON APPLICATION TO THE SECRETARY, UTICA, N. Y.

Ceiling Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Ceiling Outlet; Combination. $\frac{4}{2}$ indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

Bracket Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Bracket Outlet; Combination. $\frac{4}{2}$ indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

Wall or Baseboard Receptacle Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Floor Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Outlet for Outdoor Standard or Pedestal; Electric only. Numeral indicates number of Stand. 16 C. P. Incan. Lamps.

Outlet for Outdoor Standard or Pedestal: Combination. $\frac{6}{6}$ indicates 6-16 C. P. Stand. Incan. Lamps; 6 Gas Burners.

Drop Cord Outlet.

One Light Outlet, for Lamp Receptacle.

Arc Lamp Outlet.

Special Outlet, for Lighting, Heating and Power Current, as described in Specifications.

Ceiling Fan Outlet.

S^1 S. P. Switch Outlet.

S^2 D. P. Switch Outlet.

S^3 3-Way Switch Outlet.

S^4 4-Way Switch Outlet.

S^D Automatic Door Switch Outlet.

S^E Electrolier Switch Outlet.

Show as many Symbols as there are Switches. Or in case of a very large group of Switches, indicate number of Switches by a Roman numeral, thus; S^1 XII; meaning 12 Single Pole Switches.

Describe Type of Switch in Specifications, that is, Flush or Surface Push Button or Snap.

Meter Outlet.

Distribution Panel.

Junction or Pull Box.

Motor Outlet; Numeral in center indicates Horse Power.

Motor Control Outlet.

Transformer.

Main or Feeder run concealed under Floor.

Main or Feeder run concealed under Floor above.

Main or Feeder run exposed.

Branch Circuit run concealed under Floor.

Branch Circuit run concealed under Floor above.

Branch Circuit run exposed.

Pole Line.

Riser.

Telephone Outlet; Private Service.

Telephone Outlet; Public Service.

Bell Outlet.

Buzzer Outlet.

Push Button Outlet; Numeral indicates number of Pushes.

Annunciator; Numeral indicates number of Points.

Speaking Tube.

Watchman Clock Outlet.

Watchman Station Outlet.

Master Time Clock Outlet.

Secondary Time Clock Outlet.

Door Opener.

Special Outlet; for Signal Systems, as described in Specifications.

Battery Outlet.

Circuit for Clock, Telephone, Bell or other Service, run under Floor, concealed.
Kind of Service wanted ascertained by Symbol to which line connects.

Circuit for Clock, Telephone, Bell or other Service, run under Floor above concealed.
Kind of Service wanted ascertained by Symbol to which line connects.

NOTE—If other than Standard 16 C. P. Incandescent lamps are desired, Specifications should describe capacity of Lamp to be used.

Miscellaneous News

Baker City, Ont.—Engineer Sandberg has decided that the sum of $5,700 a year could be saved by Baker City by the installation of a municipal lighting and power plant at the cost of $17,492. Mr. Sandberg's plan is to utilize the surplus water which is now going to waste from the city's gravity water system. He figures this could be done at little outlay and that more satisfactory results could be obtained by the city.

Chicago, Ill.—The east end women of Oak Park have accomplished a temporary triumph in their fight with the village board for a street light at Lake street and North Taylor avenue, Oak Park, by placing lanterns around the entire block.

For some time they had been petitioning the village board for a light at the corner of Taylor avenue and Lake street, but have been unsuccessful.

Last night they determined to start a lighting system of their own and on a rope running from tree to tree hung lanterns around the entire block.

East Orange, N. J.—According to a report to the East Orange City Council, prepared by Henry Floy, an expert employed to look into the city's lighting facilities and the project for starting a municipal electric light plant, the city has been getting less than 50 per cent of the light from its street lamps which its contract with the Public Service Corporation calls for.

The report has created a sensation and not a little indignation toward the city officials who, it is charged, are responsbile for such a condition of affairs. Mr. Floy says he has made tests of some of the street lamps, which show that the city is getting 22 candle-power from lamps which are supposed to furnish 50 candle-power.

Mr. Floy points out that the contract between the city and the lighting monopoly "fails to cover the very important considerations which would permit the Public Service Corporation to furnish inferior illumination without violating its contract and probably without fear of detection." These are that the amount of light given out is controlled largely by the pressure at which gas is supplied and the "unfixed illuminants permit the quality of gas to depreciate even after satisfactory tests at time of manufacture."

Mr. Floy says that the contract provides that the measurements of illumination shall be made at the company's works, and the company does not guarantee any specified amount of illumination to be delivered on the street surface. He adds that the city has no redress so far as the contract is concerned, even if it were found that only five candle-power was delivered at the street lamp, though the power called for at the works be 50 candle-power.

Montreal, Can.—The new contract for electric lighting in streets and public places, it is proposed, shall cover a period of fifteen years, dating from the expiration of the present contract in January, 1909.

The tender must cover public lighting by arc and incandescent lamps, as well as electric current for private consumers. In this connection, instructions point out that the city at present makes use of 1,520 arc lamps, 90 incandescent lamps of 65 candle-power, and 335 incandescent lamps of 32 candle-power for public lighting in streets, avenues, lanes, parks and other public places in the city.

New York.—In response to the general complaint concerning the poor illumination in the subway about the stations, the Interborough Co. has begun to install more lights, especially at the 149th, 125th and 110th street stations.

The stations appeared to be very dim in the day time and the company, in making the changes believed it would reduce the possibility of accident during the rush hours, it being feared for some time that some near-sighted person might stumble over the poorly lighted platform onto the tracks below.

The benefits of the changes are already apparent. The company proposes to put in electrical power at all the uptown stations, which, when the improvements are completed, will give to the stations at least 50 per cent. better illumination.

New York (Borough of Brooklyn).—The borough of Rockaway has decided to purchase the plant and wires of the Rockaway Electric Light and Power Company. It will be operated as a municipal electric light and power plant. The borough council was a tie on the proposition to buy for $19,000, but Mayor George W. Stickle, though declaring his opposition to public ownership in small towns, has decided to cast the deciding vote in favor of the purchase, as it is the wish of the citizens.

About $5,000 will be needed to bring the plant to the highest efficiency, which will bring the total cost to the borough up to about $25,000. It is expected that the transfer will be made about January 1. Bonds will be issued to meet the cost of the improvement.

San Diego, Cal.—Articles of incorporation of the Pacific Coast Development and Securities Company have been filed here, with a capital stock placed at $1,000,000. The purposes named are to develop power for light and electricity. The incorporators are: John Campbell, Arthur Small, John K. Durrell and Frank Turnbull, and it is claimed by them that they have a large amount of English capital behind them.

Santa Monica, Cal.—Owners of property on Third street between Oregon and Montana avenues are preparing to ask for a metropolitan lighting system for the five blocks of the business center between the avenues named. No difficulty in securing the consent of a majority of the taxpayers is expected. It is planned to erect forty-eight poles with a cluster of twelve sixteen-candle-power lights for each.

Sacramento, Cal.—At a meeting of the Municipal league, held Thursday night, that body voted favorably to the proposition to establish a municipal lighting plant, as proposed by the resolution of Trustee Carraghen. The league thinks such a plant would effect a saving of over $25,000 a year to the city.

Topeka, Kas.—Mayor Davis yesterday received the report of George M. Brill, the Chicago expert who was engaged by the council to investigate the probable cost of rebuilding the city electric light plant according to present needs for lighting the streets. Mr. Brill furnished two estimates one of the cost of remodeling the present plant and one for entirely rebuilding it. The first and cheaper method will cost $65,000 and the second will foot up a total of $102,500. The first figures include the purchase of 200 open arc lamps and their installation, which item amounts to $30,000. The second plan calls for the purchase of new inclosed arc lamps throughout and consequent engineering work which will cost $49,000 of the $102,000.

Westmount, Can.—Westmount's new municipal electric street lighting service was formally set in motion on Saturday afternoon, when Councillor Lee, under whose regime as chairman of the town light committee the system has been installed, turned the switch and lighted the 150 lamps. The results are considered satisfactory, as the lamps give an excellent light, which is claimed by the townspeople to be much superior to that given by the street lights in the city of Montreal. The lamps used are of the Magnetite arc type, and Westmount is the first city on this continent to use this new lamp. The lamps are of 2,000 candle-power, and illuminate the streets brightly.

Wilkesbarre, Pa.—Following repeated protests by the citizens of Easton about the inefficient street lighting service given by the municipal plant, Mayor March has directed the City Council to either take action to obtain good service or hand over the street lighting to a private corporation.

He declares the present service is "dangerous from the police point of view and dangerous and unbearable from the point of view of the citizen."

There has long been complaint about the service, but the City Council has not been able under the conditions of the municipal operation of the plant to give the city a service which is in any way satisfactory.

In connection with the joint resolution adopted by the Councils Monday night directing the Committee on Police and City Property to advertise for bids and let contracts for lighting the streets, avenues and highways of the city, with arc lights for the term of one, three or five years, to the number of 300 or more arc lamps, it is interesting to note the rigid requirements that the successful bidder for this contract must meet in order to satisfy the demands of the city.

The specifications under which the lighting contract will be let, as prepared for the committee by City Electrician C. S. Downs, are in part as follows, the extracts giving an idea of how the city will keep tab on the lights and know whether or not the proper kind of service is being given.

All lamps shall have their illuminating value taken at an average distance of 130 feet from the lamp, and the average illuminating value shall be such as to enable 12 point type of the Standard Ryan Luminometer to be read 130 feet from the lamp, in any direction.

The lamps must be turned on 25 minutes after sundown and turned off 25 minutes before sunrise, or be kept burning about 3,811 hours a year. On dark days they may be turned on earlier or off later, this extra time being taken off on lighter days. A record of the time of turning on and off must be at all times open to the inspection of the mayor and the city electrician.

The city shall have at all times the right to cut into any or all circuits or lamps to make tests, and if three or more lamps on a circuit are found to be giving under the specified amount of light it will be considered that all the lamps on that circuit are in the same condition. The amount thus found low shall be doubled and be considered as low for the entire month, and be taken off the company's bill at the end of the month. No lamps having a frequency of less than 60 can be used.

PIONEER ILLUMINATING ENGINEERS

George N. Baird, Rear-Admiral, U. S. N. (Retired.)

The

Illuminating Engineer

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Public Lighting in Chicago

II. ELECTRIC SIGNS

By Geo. B. Johnson

COR. STATE AND ADAMS STREETS, LOOKING SOUTH.

Chicago is the City of Electric Signs. It contains more electric signs than any other city in the world. To the casual observer this may seem untrue for there is no one locality where all the great places of amusements with their large electrical outdoor displays can be seen at a glance, nor one great Broadway where the evening illumination is concentrated within range of the camera. Neither are all the large establishments on one or two streets. In Chicago the distances are so great and the city is spread out over such a large territory that it is absolutely impossible to obtain photographs which convey a just idea of the enormous number of electric signs in use. There are dozens of small business centers at distances of from three to fourteen miles from the downtown district all within the limits of the city. Every store of any size on the streets extending out to these business centers also boasts of its own electrical sign display.

In fact Chicago is veritably a City of Electric Signs, not only for the large establishments but also for the

NORTH SIDE OF STATE STREET LOOKING SOUTH FROM MADISON.

small and medium-sized stores. This is the result of the progressive and liberal policy of the Chicago Edison and the Commonwealth Electric companies in offering special inducements to the small store proprietor to use electric signs. The policy of these companies, in furnishing certain specified signs free to customers upon the customer's agreeing to keep the sign for a period of two years and guaranteeing a certain income per lamp or letter per month to the company, has resulted in the use of thousands of electric signs by merchants who would otherwise hesitate a long while before spending from seventy-five to three hundred dollars for a sign on a purely advertising proposition. The Company says to the merchant: "An electric sign will be a good investment for you. It will pay." The customer replies: "It may but I do not desire to tie up my money on the chance. 'You must show me.'" The Company then quits talking, and in the "Chicago way," acts. It is so sure that the customer will be satisfied that it ties up its own money for the customer's benefit in the cost of the sign and its installation. Out of the several thousands of electric signs installed on this basis I have yet to hear of a single instance where the customer was dissatisfied with the results. On the other hand hundreds of cases have occurred where the customer, at the expiration of the two years' contract period, has asked to have the agreement renewed.

In downtown Chicago the signs are of all varieties, sizes, shapes and effects. The photographs shown in this article were taken ten days before Christmas at about 5:30 in the evening when the traffic was very heavy. State Street is said to be the busiest

LOOKING NORTH ON STATE STREET, COR. ADAMS.

street in the world and at 5:30 in the evening is one mass of hurrying, jostling, homeward-bound humanity. The most crowded corner is State and Madison. It is estimated that 1,200,000 people pass this corner daily. The photograph of the west side of State Street, south of Madison, was taken from this corner and shows a darkened line on the walk which is the result on the camera plate of the moving throng of pedestrians. The teams and vehicles were eliminated by screening the lens at the time of greatest obstruction.

To one unused to the sight, the effect of turning into State Street suddenly after dark is startling. Standing at the corner of State and Adams and looking south is seen a grand kaleidoscope of dazzling light and color. To the left the Inde-

CLARK STREET, LOOKING SOUTH FROM JACKSON BOULEVARD

CLARK STREET, LOOKING NORTH FROM MUNROE.

pendent Drug Company looms up large and strong, while on the right is seen overhead the famous "rat-chasing" sign of Dr. Pratt, and one block farther down "The Hub" is seen with its entire frontage illuminated with the lamp-letter sign 150 feet long, which is changed weekly or daily if desired, to tell in different lettering a new advertising story. Three blocks in the distance may be seen the Elevated Loop structure spanning the street and just beyond Siegel Cooper & Co. gleams on high. Turning around we are confronted by the large one-half block-long sign of "The Fair." At the right is seen the sign of a world-known jewelry firm and at intervals in the distance can be seen brilliant, flashing insignias of wide-awake progressiveness.

Going west from State Street two blocks we reach Clark Street, the home of every conceivable kind of business. Looking south from Jackson Boulevard is seen an endless variety of glittering trade-bringers, while looking north from Monroe Street is seen a veritable potpourri of electric signs; Chop Suey and Vaudeville, Shoes and Cutlery, the alluring Dime Museum and the old reliable Boston Oyster House. The fame of Clark Street vies with that of State Street in a way peculiarly its own, but the character of the street is gradually changing from its old reputation to that of a first-class secondary business street. It is an argument in favor of electric signs that the lighting up of this street by electric signs is a strong factor in changing it into a better thoroughfare. Experience has shown that where a street formerly dark and forbidding has, through the agency of the active solictor of the electric light company, awakened out of its lethargy and subscribed for a number of electric signs, that a business revival has followed and that that section of the city has been greatly benefitted thereby, both from a financial and moral standpoint, for where the attractive electric sign enters many unattractive features vanish.

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FIG. 1.—CHRISTIAN SCIENCE CHURCH, BOSTON.

Two Instances of Modern Church Lighting

One of the most magnificent modern church edifices of this country is that of the "Mother Church" of Christian Science in Boston, an exterior view of which is shown in Fig. 1. As will be seen from the illustration, the new building is joined to the smaller and older building, the two being so connected as to form a single structure in the interior.

From an architectural point of view it is a great pity that the two buildings were thus united, as they are of entirely different types of architecture, and the older building, though of good architecture in itself, is entirely out of keeping with the magnificent proportions of the newer structure. Aside from this unfortunate combination, for which the architects were in no wise accountable, the new building must undoubtedly be classed as one of the finest examples of recent church architecture in the world.

FIG. 2.—INTERIOR OF THE MOSQUE OF ST. SOPHIA, CONSTANTINOPLE.

FIG. 3.—INTERIOR OF CHRISTIAN SCIENCE CHURCH, BOSTON.

In general plan the structure follows the basilica, having a general resemblance to one of the handsomest and most celebrated buildings of their class, the Mosque of St. Sophia, in Constantinople, an interior view of which is shown in Fig. 2. An interior view of the Christian Science Church is shown in Fig. 3. A comparison of the two views will show their resemblance in their general plan, which consist of a square central portion surmounted by a dome, with apses on all four sides. In the Christian Science church the organ loft and rostrum occupy one of the apses having a vaulted ceiling of a similar structure while the opposite one gives room for three galleries. The other apses have semi-dome ceilings, and each contains two galleries, and all the galleries are arranged in ascending order.

The decorative effect depends entirely upon the architectural sculptural features, no color being used other than the soft light gray of the sandstone which forms the main structural material. It is worth remarking that the accoustic properties of the building are apparently perfect. A person speaking in an ordinarily distinct tone of voice on the main floor can readily be heard in the upper galleries, and the notes of the superb organ cause no confusing reverberations.

Coming to the real subject of the discussion, viz: the artificial illumination of the church, the general conclusions may be given first, and the details after. The problem in illuminating engineering presented in this case is of no mean proportions, and involves conditions which are not frequently met with in the way of magnificent dimensions. The results show that the problem has been solved with a remarkable degree of success, and there seems to be not a single point, either from the scientific, esthetic, or hygienic aspect, that is open to criticism. The illumination in positions varying from the main floor to the top gallery, 40 feet above, and from the readers' desk to the remotest space under the galleries, has a remarkable uniformity; and the intensity of illumination at every point is ample for comfortable reading of ordinary print, and at no point so brilliant as to be garish and uncomfortable.

As will be seen from the illustration, the central portion of the building is lighted by eight chandeliers suspended from the dome. These chandeliers are designed of wrought bronze, and each supports three concentric rows of 32 c.-p. frosted lamps. The lamps are so connected that they can be lighted alternately, thus allowing half of them to be used if desired, as is done before the services begin. These chandeliers are arranged to be lowered for replacing lamps, being supported by cables passing over pullies in the ceiling of the dome, and operated by a windlass. A circular reflector using sixty 32 c.-p. lamps is placed above the skylight in the center of the dome. A row of concealed lamps is provided at the base of the semi-domes in two of the apses, which give the finishing touch to the general effect by the indirect illumination produced. The lower galleries receive special lighting from fixtures placed on the ceiling of the gallery above, two-inch spherical frosted lamps being used, while the passageway at the rear is further lighted by handsome 3-light side brackets, carrying 6-inch frosted globes.

On either side of the readers' desk at the corners of the rostrum are placed handsome bronze standards, supporting concentric rows of frosted lamps. Two massive side brackets, designed to suggest a torch, each carrying a cluster of spherical lamps, are placed on each of the four pilasters supporting the dome.

The subsidiary portions of the building, such as entrances, corridors, stairways, etc., have received the same careful and successful treatment. It is especially to be remarked that in no case are the fixtures so constructed or placed as to suggest their being primarily decorative features but in every case are ostensible and actual com-

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FIG. 4.—DR. PARKHURST'S CHURCH, NEW YORK.

ponent parts of the general illuminating scheme, and are designed in excellent harmony with the general structure.

The prevention of dazzling light sources is secured mostly by the use of frosted lamps, though in a few cases, particularly on the side brackets, frosted globes are used.

Considering the fact that the seating spaces have a vertical range of over 40 feet, as well as a wide lateral range (the seating capacity if the building is 5,000) the light-sources are kept out of the range of the eye to a remarkable extent. An entire evening spent in the church showed that there was no disagreeable effect produced in any way, either from excessive brilliancy of light-sources in the range of vision, or inefficient illumination. The entire edifice, as well as the general lighting, reflect the highest credit upon the architect, Mr. Brigham, of the firm of Brigham, Coveney & Bisbee, of Boston.

A church of very much smaller dimensions, but also notable as a successful departure from the traditional lines of church architecture, is shown in Fig. 4. This is generally known as Dr. Parkhurst's Church, and is located on the corner of Madison Ave. and Twenty-fourth street, New York City, opposite the enormous white marble building of the Metropolitan Life Insurance Co. This Company is to erect on the site of the old church a tower forty-five stories high, which will be the tallest building in the world. But even this Babel-like structure can never extinguish the chaste little church over the way.

In the general plan of this church the architect, the late Stanford White, also went back to the most ancient form of the Christian church, the Basilica. The outer walls of the

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FIG. 5.—INTERIOR OF DR. PARKHURST'S CHURCH.

church are of cream colored brick; the columns of the front portico of green granite; the frieze of terra cotta, tinted a delicate green, and the roof of light green and cream colored tiles set in diamond shape pattern. The dome is gilded. The interior finish is in soft "ashes of roses" tints, the wall showing the brick construction, and the oak of which the pulpits and pews are made being of the tint mentioned. No elaborate decorative scheme is used, the simple but graceful lines of architecture and the general restfulness of the color scheme giving a particularly pleasant effect.

The illumination is principally by four chandeliers suspended from the dome by chains, as shown in Fig. 5. These chandeliers are an adaptation from the chandeliers in St. Sophia. They are of wrought metal construction, finished in deep bronze gilt. The photograph from which the illustrations are made was taken nearly on a line of the lamps, so that the plan of the fixture does not show; but each circle which supports the lamps is made up of segments of smaller circles in the same manner as the fixtures in St. Sophia. The adaptation goes further than the mere general design of the fixtures. The chandeliers in St. Sophia are supplied with small glass lamps burning olive oil. These lamps have been reproduced in a remarkably successful manner by the use of Tiffany glass, and miniature incandescent lamps with pointed bulbs are used to simulate the small lamp flames. A few side brackets carrying out the same general idea are placed under the galleries.

While the adaptation of the ancient

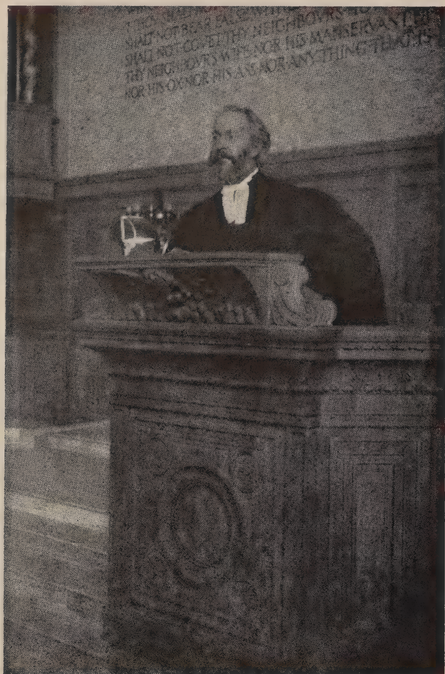

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FIG. 6.—DR. PARKHURST IN HIS PULPIT.

and well-known model has been carried out with a high degree of ingenuity, the illumination results are far from giving the satisfaction that is obtained in the former example, and the esthetic propriety of carrying an adaptation to the point of close imitation, in which the thing imitated is far inferior to the means used to imitate it, is questionable, to say the least.

Dr. Hawes, the English divine, once said that "Some things are remarkable on account of the men that did them, and some men remarkable for the things they did." Paraphrasing this, we might say that some preachers have been remarkable on account of the pulpits they have occupied, while some pulpits have been remarkable for the preachers that have occupied them. The church we have last described is certainly a remarkable example of the latter class; and we would miss much if we omitted the portrait of the man whose remarkable personality has made this little church famous throughout the world.

Pioneer Illuminating Engineers

By Geo. Wilfred Pearce

The recent retirement of Rear Admiral George N. Baird, U. S. N., from active service serves as an occasion for the older illuminating engineers in the electric field to remind the younger men of the very great services which that able and amiable officer rendered to the business when it was in its infancy.

It was difficult in the teething period of the electric lighting business to induce the Navy Department to install electric plants on board ships or in yards. It was shown by tabulated cost kept by the Edison General Electric Company, that the outgoes for the expenses of the agents who finally obtained the contract for the U. S. S. "Trenton" amounted to four times the net sum received in payment for the whole plant. The late Chief Engineer Richard Bartleman, U. S. N., was the earliest advocate for an electric lighting system on shipboard. But his recommendations were regarded as altogether too far advanced in the field of an experimental science by the fine old salts of the Navy who had gotten on well enough with mineral sperm oil.

When the pioneer electric apparatus makers began to work hard for the installation of a plant on a man-of-war, Admiral (then Captain) Baird went far to help the undertaking along by telling her designers' engineers in the lighting field just what not to do, and just what to do,

to meet naval requirements. Much that he did in this direction became standard in the whole field of electric lighting. He was well up in the field of ocean cable work, and was the first to make the suggestions about proper types of insulated ship and house wire that were afterward adopted the world over.

So it was with specifications for the entire province of installations on shipboard. Take out of the practise of these days all that Captain Baird did, and there is not a great deal left. Little of this has ever been known outside old-timers in the electrical engineering field like George W. Silsby, the late Lieut. S. Dana Greene, U. S. A., Prof. Louis Bliss and the writer, who for years handled all the United States government undertakings for the pioneer electric power and lighting apparatus corporations which maintained offices at the Capital.

It was Captain Baird who induced the Government to install electric lights in the White House and in the State, War and Navy Departments. The whole layout for the work from beginning to the end from the design of the power plant to the magnificent fixtures in the White House were by Captain Baird. That undertaking was so successful that it led directly and indirectly to an immense amount of lighting business at home and abroad for American lighting engineers.

Out of one of Captain Baird's early suggestions as to decorative lighting for a naval function grew the lucrative and artistic field of decorating by miniature lamps which was worked in thousands of magnificent schemes of decorative lighting by the accomplished Prof. William H. Meadowcraft, E. E., author of "The A. B. C. of Electricity," and for many years with Thomas Alva Edison.

Nearly all the workers in those early pioneer naval lighting undertakings at home and abroad were from New Jersey. Most of the clever men who lighted the U. S. S. "Trenton" were from Trenton, New Brunswick and Newark. One of the cadet engineers who worked on that plant afterward entered the navy for the purpose of running the plant on the "Trenton." He was from Harrison, N. J. It is narrated in an account of the dreadful typhoon which swept the "Trenton" and the other United States naval ships to destruction with nearly all hands at Samoa, that just as the American officers and men who knew that they were going to death, cheered H. M. S. "Calliope," which by the great power of its engines moved to safety in the teeth of the gale, all the electric lights on the Trenton, aloft and below, flashed out in the dense blackness, and remained alight until the ship was lost with most of her goodly crew. So that pioneer American illuminating engineer went down at his post, doubtless as courageously as the Roman sentinels, unrelieved at Pompeii, died at their posts.

One of the Edison fixture designers who worked on the early naval undertakings has since become the official artist for the Navy Department in making pictures of ships. This is Mr. C. McK. Smith, of *The Scientific American*, whose accurate drawings of men of war are famous the world over. He is a citizen of Newark, and was for several years associated with the group of former naval officers who resigned from the service to enter the field of electricity.

Practical Problem in Illuminating Engineering

VIII. HOSPITAL LIGHTING

By William S. Kilmer

The word illumination in the Edinburgh Infirmary, Edinburgh, Scotland, built in 1889 is obtained from a single open flame gas burner over each bed, with a special ventilator to carry off combustion products.

This article will treat on an installation placed in the hands of competent engineers as it was known that proper illumination forms an important factor in the modern hospital. There are many points to be criticized by the average Illuminating Engineer of today, but it is hoped it will be read in the same spirit as it is presented, merely as an aid in laying out the illumination of a hospital, as at present there is very little data published on the subject.

It was the intention of the writer to give authoritative illumination values, but an Illuminometer with any degree of accuracy could not be obtained at the time the night inspections of this hospital were made.

The Willard Parker Hospital at the foot of East 16th street, New York City, is one of the two hospitals belonging to the City of New York for the treatment of contagious diseases, it was completed in the summer of 1905 and occupied but very recently.

The plan as shown in Fig. 1 is of the third and fourth floors.

The wards are for children only. The large ward is 56 feet long, 39 feet wide and 13 feet high, the ceiling and side walls are painted French gray which reflects about 70% of the light which strikes them. The floor is of special metal and concrete construction, the prevailing color of which is light brown.

In this ward the illumination is obtained from an indirect system, the six fixtures A. B. C. D. E. & F. as shown by Fig. 1, are called the "Inverted Bowl" and are of special design for this hospital. Fig. 2 is a ¼ scale drawing of this fixture, the exterior finish is brushed brass, free from all raised work which permits easy cleaning. The interior surface of the hemisphere or bowl is coated with white enamel. The five 16 candle-power lamps to each fixture are arranged at an angle to reflect their horizontal candle-power directly to the ceiling about 10% of this light is lost by passing through a clear glass cover placed over and supported by the

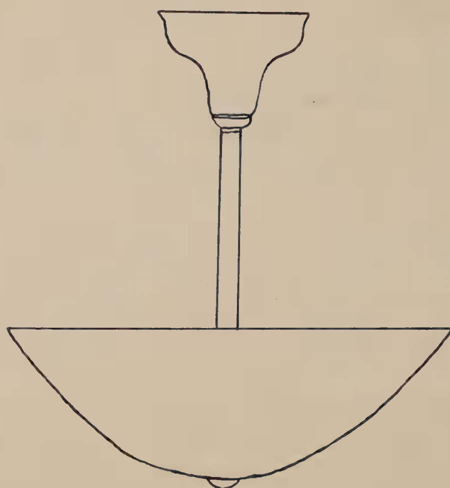

FIG. 2.

hemisphere, as this cover could be much easier cleaned than the reflecting surface of the hemisphere. These fixtures measure over all 18 inches.

Dust is almost a minus quantity in the wards as no ventilation is received directly from the outside atmosphere, but from a filtered air plant and exhaust fans.

When a fixture is burning at its maximum point (see central table and Fig. 3) a bright circle of light about 6 feet in diameter is noticeable over each fixture. This light however, is

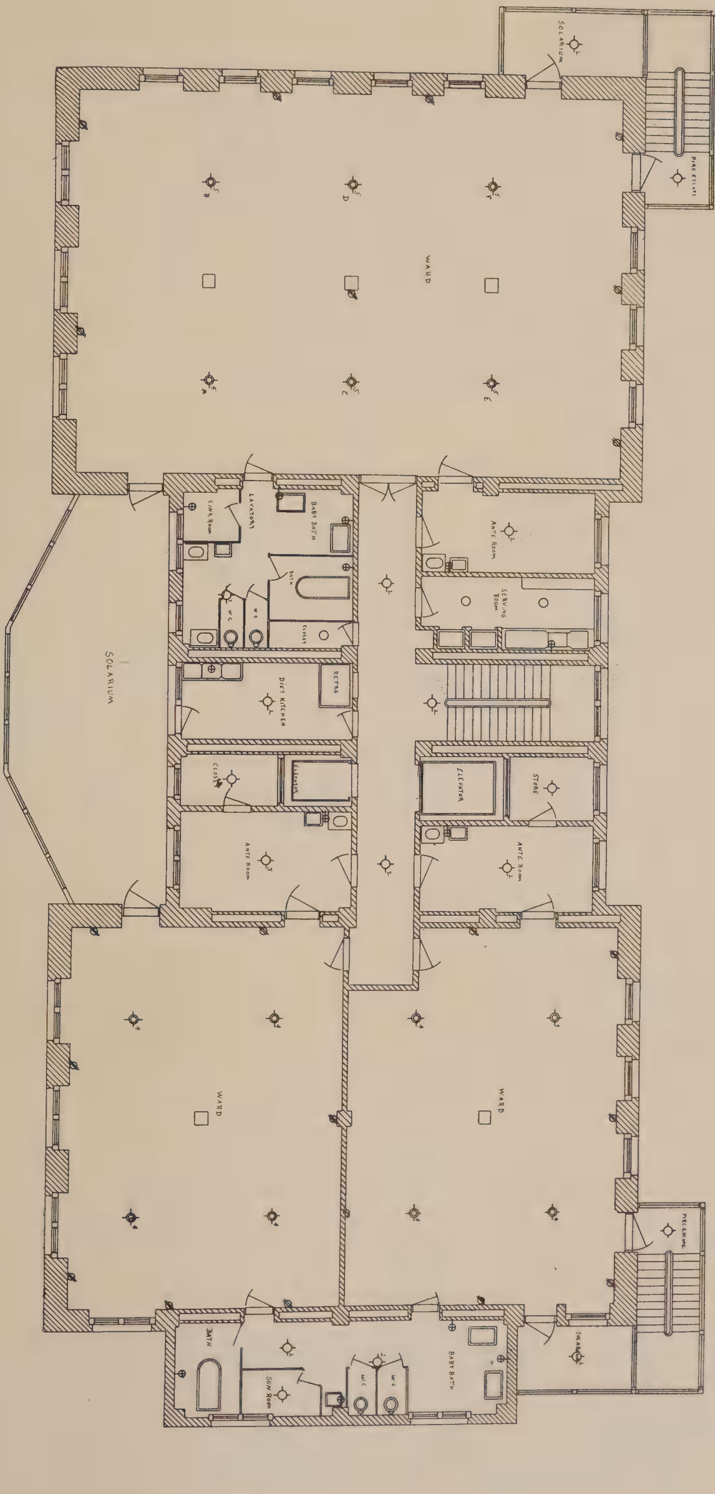

FIG. 1.—FLOOR PLAN, WILLARD PARKER HOSPITAL.

not strong enough to be fatiguing to the eye of the patient, unless it is concentrated on it for a long time. The beds are arranged around the wards close to the walls. The space in the centre under the fixtures is devoted entirely to tables and ward accessories.

The following table gives an idea of the different intensities of illumination obtainable by this arrangement, each one of them being practically free from shadows.

Circuit No. 1 by switch controls 4 lights on fixtures a and b.
Circuit No. 2 by switch controls 4 lights on fixtures c and d.
Circuit No. 3 by switch controls 4 lights on fixtures e and f.
Circuit No. 4 by dimmer controls 1 light on circuits a, b, c, d, and f.

DIMMER CONTROL:

Point No. 1,	4 circuits,	all	30	lamps burn at rated voltage
" " 2,	3 "	(Nos. 1, 2, and 3)	24	lamps burn at rated voltage
" " 3,	2 "	(Nos. 1 and 3)	16	" " " " "
" " 4,	1 "	(No. 2)	8	" " " " "
" " 5,	1 "	(No. 4)	4	" " " " "
" " 6,	reduces voltage $\frac{1}{3}$ from control point No. 5			
" " 7,	" " $\frac{2}{3}$ " " " No. 5			

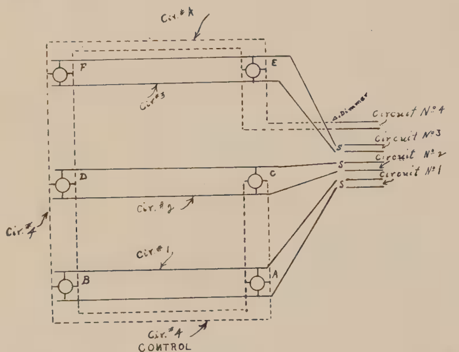

FIG. 3.

Dr. R. J. Wilson, Supt. of the hospital says "there should be a way to direct the reflected light over larger area than reducing the intensity of this circle of light." His suggestion is a series of reflecting prisms between the light source and the clear glass cover. This could be easily accomplished with only an additional loss by absorption of 10 or 12% and with that reduction it would be satisfactory as at present all pages of the *Evening Telegram* can be read easily in all parts of the ward when the lamps are burning at the maximum. The maximum illumination would be needed only in case of emergency, as would occur in case of an epidemic which would crowd the wards.

The control, Fig. 3, is governed by one switch on circuits 1, 2 and 3, No. 4 being the dimmer circuit.

The only other source of artificial light in the wards is obtained by a portable standard tripod style with a double pointed arm about 3 feet long at the end of which is used a 16 c.-p. lamp equipped with a metal parabolic shaped reflector. This fixture is used only for special examinations of a patient without any disturbance caused by raising the general illumination. The plug insertion outlets provide the connection for this fixture.

The same system of indirect lighting applies to all the wards in the hospital the only change encountered is in the small wards when a 4-16 c.-p. lamp fixture is used and 4 fixtures in each ward. These are controlled by the same method as shown in Fig. 3.

All rooms with the exception of the private laboratories and operating rooms have either the 2 or 3 16 c.-p. frosted chandelier lamps hung pendantly with no reflector or globe. The side wall brackets are of the same construction. Drop cords are equipped with a flat metal reflector about 8 inches in diameter painted white on the inside and green on the outer. These fixtures are all hung practically 4 feet above the plane illuminated; this plane being 3 feet from the floor.

The operating room on the sixth floor is the amphitheatre style. Directly over the operating table is a 12-16 c.-p. lamp fixture which can be raised or lowered by a pulley attachment. The lamps are arranged in a circle

about 36 inches in diameter each lamp hanging at an angle of about 45° reflection coming from mirrors arranged over and back of the lamp. This is a source of great dissatisfaction to all who use this room. The principal complaint being that when this fixture is lowered to 2 or 3 feet from the operating table another complaint is the eye strains. There are 2 insertion plug outlets in this room for either small motor power or portable lamp fixtures.

The private Laboratories have very recently adopted the high efficiency (2.5 w. p. c.) for both general illumination and special instrument lighting where usually a high candle-power is needed in a small space.

Experiments are now being carried on with these lamps with various equipments. A report dated January 12th, states that the 250 Watt G.E.M. unit with a concentrating type reflector gave the best results, those of a lower candle-power did not furnish sufficient illumination to see the objects clearly which were being examined. The tantalum lamp with the multiple filament did not give a sufficient amount of light to begin with, and in the second place, the multiple filament was reflected from the mirror into the microscopical field, thus interfering with the examination of the objects; when low power lenses were used it gave sufficient light.

A lamp with a spiral filament of about 100 c.-p. would be the ideal lamp for this purpose.

INCREASED CURRENT RESISTANCE OF ALLOYS

By F. M. F. Cazin

The Cazin-Filament, consisting of metal-alloys, is in itself full proof and evidence for the fact that alloys offer to the electric current a higher resistance than single metals.

No single-metal filament of the same transverse section as that of a Cazin-Filament, selected for the comparison, will, when also of the same length, offer sufficient resistance to incandesce and produce useful light, while the Cazin-Filament produces a brillant white light, which has no yellow and no reddish tint, such as a pure carbon-filament of the same dimensions will produce, when subjected to a current of the same tension, though requiring a higher wattage.

Lord Rayleigh has correctly stated (Nature, June 1896 and Collected Papers, Vol. IV., page 232) the fact of higher resistance by alloys, the correctness of which statement is not made doubtful by Dr. R. S. Willows' and Prof. J. A. Flemming's statement, that they had been unable to corroborate it. But Lord Rayleigh's explanation and theory for the phenomenon remained unproven for the same causes, for which the Willows attempts at corroboration remained unsuccessful.

The correct theory, explaining the fact of higher resistance by alloys than by single metals, requires consideration of two qualities of the component metals as such, namely of their ductility and their density.

Resistance increases, as ductility lessens, and decreases, as density increases, and in this the alloys participate.

It is on that account, that the non-ductile and high-density metals of the Osmium-Ruthenium class have been selected as predominating in the Cazin-filament, and that their alloys are used, since by the treatment required for singling out some of the metals used, ductility is imparted where the metal in its native or natural state possesses none, and their natural density is lessened. The Cazin-filament is an electrolytic alloy, in which the component metals have preserved their natural qualities, and the product is not even impaired in its resistance by a small admixture of ductile metal, so admixed to increase the cohesiveness of the alloy. A resistance is shown, which produces a brillant white light under conditions, under which neither carbon nor single metals in the same dimensions produce any useful light.

Plain Talks on Illuminating Engineering

By E. L. Elliott

VI. THE EYE AND VISION — COLOR VISION

THE EYE AND VISION (Concluded)

[Note.—The rule for finding the intensity of illumination on a horizontal surface given in our last article in the December issue was inadvertently mis-stated. The following is the corrected rule:

Multiply the candle-power intensity of light at the given angle by the reduction factor for that angle, and divide the product by the square of the height.

It is important that this corrected rule be substituted for the mis-stated rule as given in the preceding issue.]

The foregoing parallels between the eye and the photographic camera are exact, since in both cases they result from the purely physical laws of optics, but the eye, owing to its peculiar physiological qualities, is susceptible to certain injuries which have no exact parallel in photography. Like any other organ in the human body, the eye adapts itself to the conditions to which it is ordinarily subjected. When, therefore, it is subjected to other conditions than these, it is unduly fatigued or strained.

We may first notice that the iris or stop of the eye only varies in diameter within certain rather narrow limits, and furthermore requires a little time to adjust itself. Having, for instance, adjusted itself for a dim light, by opening to its full diameter, if immediately brought into a brilliant light, perhaps a half minute or more is required for the iris to contract to its minimum. Meanwhile more than the usual amount of light is falling upon the retina, which causes discomfort or pain. If a light varies in intensity rapidly, so that the eye does not have time to readjust itself, the continuous strain may result in permanent injury. A flickering light is, therefore, always to be avoided. Light which produces alternating streaks of light and shadow upon the object, particularly if this object is a plain surface, as of paper, is equally bad, producing the same effect upon the eye as a flickering light. An incandescent electric lamp suspended above a paper produces these light and dark streaks very distinctly, and should, therefore, never be used in such a position for reading or writing unless a frosted lamp or diffusing globe is used over it.

The iris also adjusts itself to the brightest part of the retinal image. If, therefore, there is a luminous body in the range of vision, the iris will adjust itself to the intensity of this part of the image; and as luminous bodies are always of vastly higher intensity than non-luminous bodies, the result is that the iris closes so as to reduce this intensity on the retina, and thereby darkens the image of the non-luminous objects. If the luminous body is particularly brilliant and kept continually in the field of vision, the eye will make a further attempt to screen the retina by partially closing the lids so as to use the eyelashes as a shade, giving rise to the "squinting" expression which involuntarily takes place on looking at a bright light. The difficulty of looking at non-luminous objects beyond, or past, a luminous body is due to this cause. The importance of subduing the intrinsic brilliancy of all light-sources that can come into the range of vision cannot be overestimated. A fair test of adequate diffusion is the ability to look past the light-source and see objects beyond it with distinctness and ease. These facts explain why a frosted lamp or diffusing globe, while actually reducing the amount of light given

out, increases the illuminating effect; that is, enables the eye more readily and with greater ease to see the illuminated objects.

When light falls upon a photographic plate, it produces a chemical change which is permanent, i. e., it requires a considerable chemical manipulation to put the substances back again into their original sensitive condition. When light falls upon the retina of the eye, it likewise produces chemical changes; but the eye has the ability to continuously renew its sensitive condition. This renewing process, however, is limited; and it is possible to so exhaust the sensitiveness of the retina as to necessitate a period of complete rest in order to restore the eye to its former condition. Such exhaustion results more quickly when the light is colored.

COLOR VISION.

Although color is not an essential of vision it must not be inferred that the study of color effects is of no importance to the Illuminating Engineer; on the contrary it is a matter which should receive careful attention. The theory of color is perhaps the most complicated of any of the subjects with which Illuminating Engineering has to deal, and is by no means fully understood nor agreed upon by scientists who have made it a special study. The complication arises from the very intricate physical and chemical problems involved; furthermore, the final results depend upon physiological actions which are still more difficult to analyze. It is not necessary, however, for ordinary purposes of Illuminating Engineering that these recondite theories be mastered; if the simpler and generally accepted portions of the theory be understood, it will be sufficient for practical purposes.

It may facilitate an understanding of the theory to compare light with sound. We stated in the beginning that sound and light are both due to vibrations, and that color in light is the counterpart of pitch in sound, the red rays corresponding to the base, or lower notes, and the violet to the higher notes of the scale, while the colors correspond to the intermediate notes. A sound is never made up of vibrations of a single rate, but is always a combination of vibrations of different rates; and the same is true of light as ordinarily produced. The difference in *quality* of sound, which enables one to distinguish between the sounds of different musical instruments, is due to the different vibrations of which the sounds are composed; and the difference in color which we call "shades," or "tints," is due in a similar manner to the different vibrations, or colors, which combine to form the tint. By analyzing the tone produced by a particular musical instrument—say for example, a flute—that is, finding all the different rates of vibration which are blended in its notes, it is possible, by producing all these different rates of vibrations by separate means and combining them, to produce a sound having the same quality. This has been done in a most remarkable manner by Prof. Cahill, in the instrument which he calls the "Telharmonium," which has recently attracted much public attention. In an exactly analogous manner it is possible to produce any given tint or shade of color by combining single colors in certain proportions. It is a rather remarkable fact that the process of combining single colors to produce different shades, or tints, is far simpler to accomplish than the reproduction of sounds of given quality by the composition of simple sounds.

Most of the elementary text-books divide the color scale into seven so-called "primary colors." The color-scale is the "solar spectrum," of which the rainbow is the familiar example; and the seven divisions as given are: violet, indigo, blue, green, yellow, orange, and red. This division, however, is a purely arbitrary one, as can be readily shown. So far as vision is concerned, there are only three primary, or fundamental colors: red, yellow, and green.

It may be well to distinguish here

the difference between the visual and physical meaning of color. Physically, there is an infinite number of colors, since each different rate of vibration produces a different color; but in the study of illumination we are only concerned with visual effects, i. e., things as the eye sees them.

The fact that all tints may be made up of varying mixtures of the three primary colors is not a new theory, having been advanced by Leonardo De Vinci, the celebrated Italian painter who flourished in the sixteenth century. No practical applications of the theory were made, however, until a few years ago. The most important original work in this line was done by Mr. F. E. Ives, who practically accomplished photography in natural colors. It is one of the pecularities of fate that Mr. Ives has never received the recognition which his exceedingly valuable work and discoveries in this line justly entitle him. Briefly described, the method of producing pictures in their natural colors as carried out by Ives is as follows:

Three different plates are prepared which are sensitive to green, yellow, and red respectively. With these three plates photopraphs of the given object are taken. The three different photographs are then colored the respective colors, and superposed upon one another in such a manner that all three are seen at once. The most effective way of accomplishing this is by making transparencies or "lantern slides," which may be thrown upon a screen at the same time one over the other.

For commercial purposes, however, it is necessary that the picture be produced on paper, and for this purpose, three different photo-engraved ("half-tone") plates are produced from the three negatives taken, and these three plates printed with the different colors one over the other. This process is illustrated in the plate used as a frontispiece of this issue

The foregoing description of the mechanical method used in printing to produce pictures in colors has been given as an interesting practical illustration of the general nature of color vision.

Color, as a quality of light, is ascribed to both luminous and non-luminous bodies. The causes of the color are different in the two cases. An ordinary flame is yellow, bordering more or less on the orange tint, due to the fact that it gives out more powerful rays of this particular color (i. e., rate of vibration) than the other rays. It may be compared with a sound made up of several notes of different pitch blended together, one particular pitch being much louder than the others, and therefore determining the pitch of the tone as a whole.

Non-luminous bodies are seen by the light which they reflect. The color ascribed to the body is, therefore, evidently the color of the light reflected. Thus, a red object is simply one that reflects red light to a sufficiently greater extent than the other colors to give the eye the single impression of red. When light containing all colors, i. e., so-called "white light," falls upon such an object, it is evident that all the colored rays except red must be absorbed; in other words, considering that light is made up of the three colors, red, yellow, and blue, a red body is one which absorbs the yellow and blue light falling upon it, and reflects the red. Similarly, a blue object is one which absorbs the red and yellow rays, and reflects the blue; and a green object, one which absorbs the red, reflecting the yellow and blue rays, which together give the visual impression of green.

This latter point brings to our attention the phenomena of "complimentary colors." Complimentary colors are usually defined in the textbooks as those, which, if combined, would give white. For example, red and green; since green consists of yellow and blue, and yellow, blue and red together constitute white light. Every color, therefore, has its complimentary color. The fact that complimentary colors placed side by side produce a pleasant visual impression is one of the un-

der-lying principles of the use of color in decorative art.

A consideration of the facts just given will show why objects appear of different color when seen in different colored lights. Thus, an object is red when it absorbs yellow and blue rays. If a red object were illuminated by green light only, it would theoretically appear black, i. e., it would not reflect any light. The mercury vapor lamp gives out no red rays, and, therefore, red objects can not be seen by this light in their proper color. The rays from such a lamp are very largely blue, while the prevailing colors of the face are light tints of yellow and red. Yellow, being a complimentary color of blue, will appear gray when illuminated with blue rays; which accounts for the peculiar ashen pallor which is given to the face by the light of a mercury vapor lamp, and also for the preference for the light of flames and incandescent electric lamps, in domestic and other illumination in which faces are the principal objects to be considered, the orange-yellow rays of such light-sources giving a natural hue to the complexion.

When flames were the only practical light sources, the considerations of color were of minimum importance to the illuminating engineer, since it was impossible to vary the orange-yellow color of general illumination to any considerable extent. Within the past few years, however, commercial light sources have been produced having a distinctive color effect; the mercury vapor lamp being the most decided, while the carbon arc, with its excess of blue and violet, the incandescent gas mantle, with its tendency to green, and at best distinctly yellow, the vacuum tube light which is a "*cerise*" in tone, and the flaming arc, with its intense deep yellow, all give considerable variations from both the white of daylight, and the familiar orange-yellow of flames.

The ideal color for artificial light is naturally one which approaches to the quality of sunlight; and it is gratifying to know that the most recent improvements in light production approach more nearly to this ideal than anything that has heretofore been in practical use. Acetylene gas flames must be included in this class, since the light they produce is the nearest approach in color quality to daylight of any source at present in commercial use, although the newest forms of incandescent electric lamps promise to be almost, if not quite, as favorable in this respect.

As opaque bodies owe their color to the absorption of certain color rays, and the reflection of others, so transparent bodies likewise owe their color to the particular color rays which they allow to pass through them. Thus, red glass obstructs the passage of blue and yellow rays, allowing only the red, or at least a great preponderance of red rays, to pass through; and similarly for other colors.

A simple and instructive series of experiments may be made by producing a pure yellow light, which may readily be done by placing a little common salt on the wick of an alcohol lamp or on the cap of an incandescent gas burner, adjusted to give a non-luminous flame, and examining different color objects by this monchromatic (single-color) light.

Daylight Illumination

By O. H. Basquin

III. BRIGHTNESS OF THE SKY (Concluded)

If we make this assumption for Figure 6 then we have

$$B = 20\,(P - 30). \quad \text{Eq. 2.}$$

in which B is the mean daily brightness of any month and P is the mean percentage of sunshine for that month. It seems that the constants in equations 1 and 2 above should be the same. The figures were drawn independently and it is quite likely that a selection of constants could be made which would be the same for both equations and bring the curves in both figures more nearly into coincidence. Such constants, however, would not be round numbers and would introduce a double set of rulings in the figures.

We have seen that the average monthly brightness of the sky overhead varies throughout the year in a fairly regular way and in a manner which resembles the variation of the percentage of sunshine. The above result is experimentally known only for Chicago 1897-1899, but in the absence of reliable information with regard to the sky brightness at other places we may tentatively assume that the result found for Chicago is of general application. It is admitted at the start that this guess is very likely to be inaccurate, but it is only suggested that this rule be used until something more definite may be found out. Taking observations upon the sky brightness is to be particularly recommended to individuals who may have a desire to aid in pushing forward our knowledge of daylight illumination.

It is possible that some relation may be found between cloudiness and the brightness of the sky. Records of cloudiness have been kept by the Weather Bureau for a great many years and a table and map of average cloudiness are contained in the Annual Report of the Weather Bureau for 1897.

For the purpose of estimating the approximate annual brightness of the sky (B) in any locality, let us tentatively assume that the relation is general which we found at Chicago between this brightness and the percentage of sunshine (P). This relation was expressed in equation (2) as B=20 (P-30). In order to make this relation available for immediate use, the map shown in Fig. 7 is given here rather than under the study of sunshine.

Sunshine records for over a hundred different stations widely scattered over the United States are published in the Annual Reports of the Weather Bureau. This map is based upon these reports. The lines on this map connect places of approximately equal percentages of sunshine and these lines are given for every five per cent variation in sunshine. Phoenix, Arizona has the record of highest average percentage of sunshine—84%—while Elkins, a small town in the mountains of West Virginia has the record for least sunshine with a percentage of 36% the average for four years. It is not unlikely that the records for the large cities somewhat misrepresent the country surrounding them on account of the smoke hanging over all large towns.

At Buffalo the sunshine percentage is seen on the map to be about 50 so that we may estimate its average sky brightness to be not far from 400 candles per sq. ft. At San Francisco we see the sunshine percentage must be near 65 so that if our relation holds good the average sky there is more than twice as bright as the sky at Buffalo.

We must not expect the same distribution of sky brightness throughout the day and throughout the year

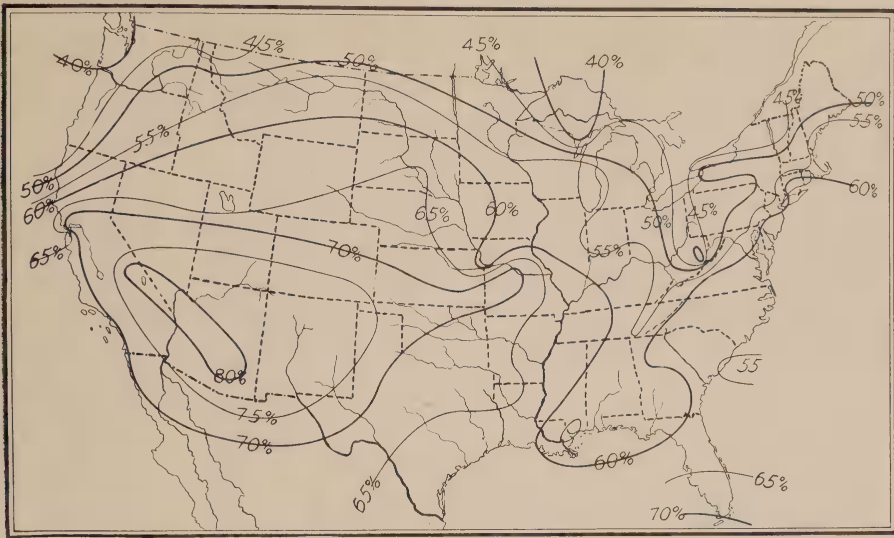

FIG. 7.

in other localities as was shown for Chicago unless they have a similar distribution of sunshine. In New York and in Boston the percentage of sunshine is nearly constant for all months throughout the year. In Chicago and in Cincinnati there is much more sunshine in summer than in winter, the maximum coming in July. At Mt. Tamalpais, a station near San Francisco, the percentage of sunshine is nearly uniform throughout the day from morning to night, at San Diego, in southern California, there is much more sunshine in the afternoon than in the morning, while in Chicago as was seen above in Fig. 5* the percentage rises throughout the forenoon to a maximum not far from midday and sinks again in the afternoon in a symmetrical fashion. For further details in this line the reader may consult the reports mentioned above.

In the British Isles the records published for 1881-1890 show the percentage of sunshine for their towns to be roughly between 25% and 30%, or about half the usual value in this country. A part of this difference between the sunshine percentages for the two countries may possibly be accounted for in the different types of instruments used in taking the record. In the British Isles the sunshine in summer is about double that in winter.

Variation From Average Brightness. All the values of the sky brightness thus far referred to have average values and the shortest period over which the average has been taken has generally been one month. We may now inquire how the various values of the sky brightness for any one hour of observation on different days of the month agree among themselves and with their mean. For any month in the observations taken at Chicago the average variation from the mean brightness is about fifty per cent. of the mean value. This is found by first taking the difference between each value for the different days and the monthly mean, second finding the average of these differences and third, dividing this average difference by the average monthly brightness.

The meaning of this is that for any month the brightness of the sky on a number of days may fall as low as half the average monthly brightness and that on one or two days—and sometimes even on a third—the sky brightness will fall considerably below

*Page 828 (December number).

this half-average. On a few days also the brightness is likely to run up to double the average value, but this does not interest us so much as the low values because one is hardly ever troubled with too much light from the sky but we are seriously troubled when the illumination of our shops and offices falls below a fairly definite working minimum.

That we should have expected this large variation from the average brightness is easily seen when we remember that the different classes of sky have a very different brightness and no class is altogether absent from any one month. It would be unreasonable to ask one to provide good daylight illumination for a room during a heavy storm—one must always expect to light the lamps in such cases. Furthermore when the sky is free of clouds and blue in color it is impossible to give good skylight illumination. Daylight illumination in such cases as the last comes from direct and from diffused sunshine, a subject which will be taken up later. These two classes of sky, the stormy and the clear blue, account for the failure of the sky brightness to come up to half its average value on one or two days per month. We see also that we shall be fairly safe in using half the average sky brightness as a working minimum value.

In what follows we may use 250 candles per square foot of opening as this working sky constant for the year and if the mean brightness for any particular month at Chicago is desired one may modify this yearly value in such way as will be suggested by reference to Fig. 6*.

It is interesting to note that the average difference in the brightness of the sky on *successive* days is also about 50% of the average brightness for the month. One would expect this to be nearly double the variation from the mean instead of being nearly equal to it. This is probably the result of the fact that the weather for one day is closely related to that of the preceding day. We are all familiar with the pendulum-like variation in the brightness of days; two or three bright days generally come together to be followed by a similar number of darker ones. On any day then one may expect the sky on the following day to be either brighter or darker by about 50% of the average brightness for the month. While this variation seems larger when written down in black and white, it is small in comparison with that for which the eye is adapted.

Country Sky. The zenith is the direction immediately overhead, and angles measured from the zenith are spoken of as zenith angles or zenith distances. In all the preceding discussion upon the brightness of the sky it is only the zenith sky to which reference has been made. Let us now consider another problem, namely, how the brightness in other parts of the sky is related to that in the zenith. We must first agree to leave the sun out of consideration in this part of the discussion. It is convenient to take up sunshine by itself and here consider the sky as made up of clouds, dust, etc., and entirely apart from the sun.

Let us picture to ourselves a typical sky of the second class* and free from smoke: the sky is overcast, no blue sky is to be seen and generally the sun also is invisible. We may assume that this sky is the result of sunshine upon a layer of cloud spread over the earth something like a great white blanket high in air. We shall assume this layer to be uniformly thick and everywhere made up of the same kind of cloud. If this last assumption is not strictly true at any particular instant, it will be true on the whole because, except in very special cases, we have no reason for thinking that the clouds in any one locality are, on the average, different from those over any other locality in the same neighborhood.

*Page 829 (December number).

*For sky classification see page 825 (December number) or briefly in summary at the end of this article.

This case is represented in vertical section in Fig. 8. The observer is at A with the ground shown below him and his zenith immediately overhead.

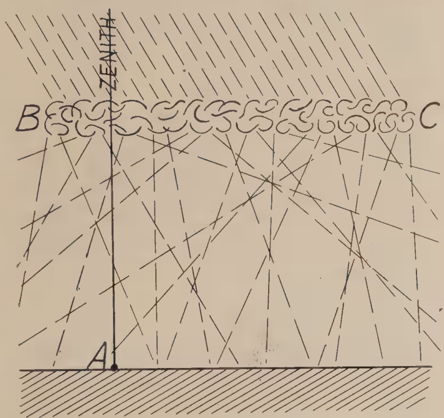

FIG. 8.

The uniform layer of thick cloud is represented by B-C, which we must imagine extending indefinitely to the right and left. Upon the upper side of the cloud the sunshine is falling as suggested by the parallel broken lines. The different rays of sunshine, incident upon the cloud are scattered by it in all directions. In the figure, this is suggested by the mixture of broken lines between the cloud and the earth. We must remember that the cloud throws out this diffused light from the upper surface as well as from the lower, but we are not interested in this, as it goes off into space and is lost so far as the illumination of our planet is concerned. One can make a good model of this cloud as above described by filling a glass tray with clear glass beads and suspending them under an electric lamp.

The upper surface of the cloud is uniformly illuminated by the sunshine since the cloud is too near the earth to make the curvature of the earth's surface appreciable in this connection. If the cloud is so thick that one cannot see the sun through it we may be pretty certain that the light is very well diffused or scattered and on the basis of Lambert's law, which must apply perfectly in this case, the effect of this is to make the cloud appear equally bright at the point A, Fig. 8, no matter from what direction it may be observed. For the conditions then assumed to represent the second class of sky when free from smoke as we have it in the country and small towns, we are justified in taking the sky to be of equal brightness in all parts and in all directions. To many people it is probably easier to think of this sky as the interior of a uniformly bright sphere and for most purposes there is no objection to this mental picture.

For classes of sky which we have numbered three and four, in which there is a mixture of bright clouds and of blue sky the assumption of uniform brightness cannot be made for any one instant, but for the average condition it is not at all clear that this assumption is far from the truth. The case is complicated by the fact that in the extreme distance one sees only the lower surfaces of the clouds, in the middle distance he sees also their sides or edges as well as some blue sky. While over head he sees only the lower surfaces of the clouds and blue sky alternately. From this one might suspect that these skies would on the average be brightest near the horizon and darkest at the zenith, however, as no trustworthy data are at hand upon this point and as a small amount of smoke has the effect of reducing the brightness of the sky near the horizon in comparison with the remaining sky, as will soon be pointed out, we shall tentatively assume uniform brightness for these classes of sky.

The stormy sky and the clear blue sky give too little light for serious consideration in this connection. The hazy clear sky is probably nearly uniform in brightness except in a rather large region surrounding the sun, where it increases in brightness near the sun. The position of the sun is however so variable during the day and throughout the year that it is

hardly worth while to give further consideration to this variation of the hazy clear sky. This leaves all classes of sky for the country and small towns to be assumed of uniform brightness.

City Sky.—To one whose home lies within a radius of twenty or thirty miles from a large city a familiar sight is the layer of smoke hanging over the city and drifting with the wind, first to one side and then to another. On a still day it may be seen piling up to a considerable height over the city, but generally it is carried to one side in a layer of approximately uniform thickness.

We think of smoke as made up of a cluster of small particles of black solid matter each of which absorbs practically all the light which happens to strike it. The likelihood of any ray's striking some particle of smoke and being absorbed depends upon the density of the smoke and the length of its path through the smoke. With a given thickness of layer and a certain density of smoke and with light passing directly through it, the proportion of the light absorbed by the smoke will be the same whether the incident light be strong or weak.

In Fig. 9 we may think of "I" and "II" as blocks of glass or smoke or any other substance fulfilling the condition that each block absorbs, we will say, one-half the light trying to pass through it. We may think of "A" as rays of light falling on block "I" while "B" represents these same rays of light coming out of the block and reduced in intensity by one-half. These rays then fall directly on the second block "II" which in turn reduces the intensity of the rays by another half so that the emergent rays "C" have only one fourth the intensity of the incident rays "A".

In general if a given thickness of smoke absorbs a certain ratio m of the incident light then the proportion of the original light which gets through is $1-m$. If the light must pass through twice the above thickness of smoke or glass the proportion of the incident light which comes out will be $(1-m)^2$. If it passes through a layer three times as thick as the first the proportion getting through will be $(1-m)^3$. Finally if it passes through n thicknesses of the absorbing material, as above, the proportion of the incident light emerging will be $(1-m)^n$. We shall be interested in the ratio of the light leaving the nth thickness to that leaving the first thickness and it is easy to see from the above that this ratio is $(1-m)$.

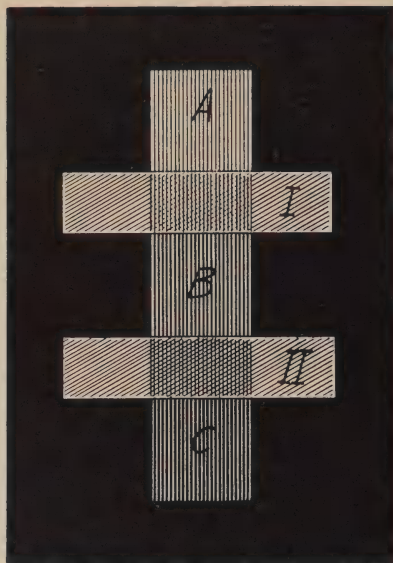

FIG. 9.

We may now come back to the layer of smoke hanging over the city and apply the above last mentioned formula to it. Fig. 10 represents this case. We assume the above mentioned uniform cloud extending in all directions and below this a uniform layer of smoke, as shown. The observer is at A. The light from the cloud immediately over his head passes along the line marked "1" and goes through a single thickness of smoke. The light coming from the cloud toward A at an angle of 60 degrees from the vertical, as shown by the line marked "2", passes through a double thickness of smoke. Following this up the rays shown by the lines 3, 4 and 5 include

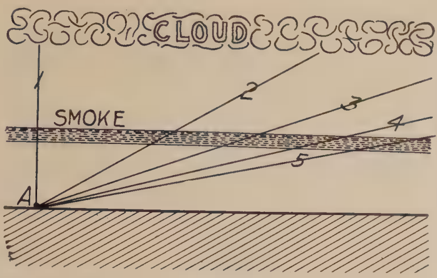

FIG. 10.

in their respective paths smoke equivalent to 3, 4 and 5 times the actual thickness of the smoke layer. It will be at once seen that the length of the path of any ray through the smoke is directly proportional to the secant of the angle which that ray makes with the vertical.

If the layer of smoke absorbs a ratio m of the incident light coming along the direct path marked "1", the ratio of the transmitted light, to the incident light along this path will be $(1-m)$. The fraction m may be called the absorption coefficient. Light coming along any direction making an angle (θ) with the vertical will be reduced to the proportion $(1-m)^{\sec\theta}$ The ratio (R) which the brightness of the sky at any zenith-angle (θ) bears to the zenith brightness will be given by,

$$R=(1-m)^{\sec\theta - 1} \quad \ldots\ldots\ldots\ldots 3$$

The interpretation of this equation is shown in Fig. 11. We may think of the observer as standing at "A" and as comparing the brightness of the sky at various zenith angles with the brightness at the zenith. The zenith angles are given along the circular arc at the right. The brightness of the sky in various directions as compared with that at the zenith is represented by radii drawn from A in the corresponding directions. If the sky is uniformly bright as seen by the observer this radius, representing its brightness, will be everywhere of unit length, and will everywhere touch the circular arc shown in the figure. If the sky is covered with a uniform layer of smoke which absorbs 20% of the zenith light, then the curve marked "$m=20\%$" represents the variation in brightness of the sky from the zenith to the horizon. At a zenith angle of 60° as shown by the radius marked "60°" at the right, this 20% curve crosses the arc marked "0.8" at the bottom. This means that the sky in this direction is eight-tenths as bright as the zenith sky. At a zenith angle of 70° the brightness of the sky is seen to be about 65% of that at the zenith, while at a zenith angle of 80° the ratio of brightness falls to about one-third. At zenith

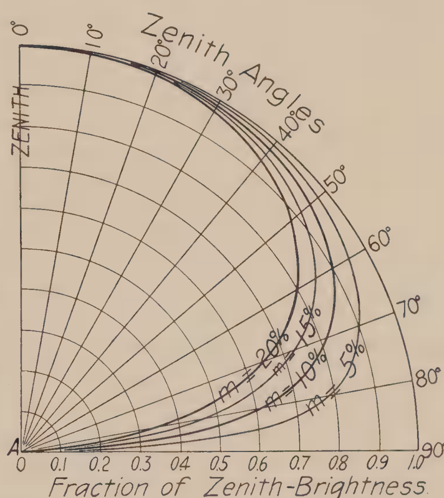

FIG. 11.

angles smaller than 60° the brightness does not differ very greatly from that at the zenith.

If the layer of smoke absorbs only 10% of the vertical light, we may then find its effect upon the relative brightness of the sky by studying the curve in Fig. 11 which is marked "$m=10\%$". The other curves shown in the figure may be used in the same manner.

It will be noticed that the brightness of the sky at a zenith angle of 60°, in terms of the zenith sky, is always equal to $(1-m)$. The 20% curve crosses the 60° radius at 0.8 and the 10% curve crosses it at 0.9. This comes from the form of the expression for this ratio as given in equation 3. The secant of 60° is 2,

so that the exponent of the parenthesis, $(1-m)$, becomes unity for this angle or $R=(1-m)$. This relation points to an easy way to judge the absorption coefficient, m, of the layer of smoke at any time and place. One needs simply to compare the brightness of the sky at 60° with that at the zenith.

No measurements of this absorption coefficient are known to the writer. It is to be hoped that they may be investigated for a number of cities in the near future. They form a true standard of the smokiness of towns and should therefore be of interest to the general public as well as to the illuminating expert.

It was noted above that when the coefficient of absorption, m, is small, the upper portion of the sky is of nearly uniform brightness. It may now be seen that if the smoke piles up over a city, so that it cannot be considered as a uniform layer, then for the city sky it will have the effect of darkening the upper portion more than the lower portion, or the sky will be more nearly uniform in brightness than shown in Fig. 11. Moreover in cities, on account of surrounding buildings, it is in general only the upper forty or fifty degrees of sky that are available for illuminating the more important floors of buildings. In cities, then, it is evident that for most cases the error will not be large if we consider the sky of uniform brightness from the zenith down to within about 20 degrees from the horizon, and in some cases it may be advisable to disregard sky below this limit.

Summary.—In summarizing the above discussion of the brightness of the sky we may enumerate the following points:

1. The brightness of a small luminous surface is the ratio of its candlepower in a direction at right angles to the surface divided by the area of the surface.

2. An opening in a roof or wall through which the sky is seen may be considered as a luminous surface, and its brightness is called the brightness of the sky, the area in question being measured at the opening.

3. The classes of sky described as (1) stormy, (2) overcast, (3) more than half cloudy, (4) more than half blue, and (5) clear, have at Chicago an average brightness of about 200, 600, 500, 400, and 300 candles per square foot respectively.

4. The brightness of the sky at Chicago follows the percentage of sunshine through the day and year approximately by the relation $B=20(P-30)$, which equation is tentatively assumed to hold for other localities.

5. The distribution of annual sunshine in the United States is shown on the map Fig. 7.

6. For any one month the average variation in sky brightness from the mean monthly brightness is about 50% of the mean value.

7. On the average, a sky free from smoke is uniformly bright in all directions.

8. Smoky sky is bright overhead but becomes dark at a rapidly increasing rate near the horizon.

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THE LIMITS OF ACCURACY IN ILLUMINATING ENGINEERING

It has been generally admitted that the methods of measurement, and the calculations based theron, which form the mathematical basis of illuminating engineering, are not susceptible of the high degree of accuracy which pertains to other branches of engineering work. In fact, there are doubtless many who still believe that there is not sufficient opportunity for the use of mathematical methods to justify the use of the term "engineering" in connection with illumination. The fact that apparently good results have been obtained without any such recourse to mathematics, and the general prevalence of "rule of thumb" practises have doubtless contributed largely to this opinion. Up to the present there has been very little data available showing the relation between the calculated and the actual illumination obtained.

Probably the first reliable information of this kind on an installation of sufficient size to render the results valuable was that given by Mr. Lincoln Smith in the *Quarterly* of the Massachusetts Institute of Technology in 1902. As his valuable paper was not largely circulated at the time, we have thought it worth while to reprint in this issue. It will be seen that the results which he obtained were on the average within 6.6% of the theoretical values calculated; and that while the maximum difference was 27.2%, such a deviation was unusual, and was accounted for in nearly all cases, so that the maximum deviation was practically not more than 10%.

From these cases, however, it is evident that the strictly engineering features of an illumination problem are capable of very much more exact handling than has generally been supposed; in fact, the limits of error within which results may be confidently expected to fall are as close as in the general run of problems in other branches of engineering science.

THE NEWEST HIGH EFFICIENCY INCANDESCENT LAMPS

The term "new high efficiency incandescent lamp" has already become ambiguous. Since the possibility has been shown of producing filament material capable of much higher efficiences than the carbon that has held the field for the past quarter of a century, there seems to be no limit to the number of elements or combinations of elements which are available for the purpose. The tantalum lamp has been before the public scarcely more than a year, and as yet cuts but a small figure in commercial lighting; and yet within this time at least a half-dozen methods have been announced for producing lamps of even higher efficiency and superior durability.

The latest of these methods to claim attention is the result of the work of American experimenters. We refer to the lamp recently exhibited before the American Physical Society in this city by professors Parker and Clark, of Columbia University, a description of which will be found in the re-print of papers read before technical societies in this issue. While the writers do not give a full description of their process of making their filament, one quite remarkable point is brought out,

namely, that the principal constituent of the light-giving portion is silica. A property of their filament equally remarkable is its power of giving a much higher visible radiation at a given temperature of incandescence than either carbon or the infusible metals of which so much has been heard within the past few months. Still another remarkable quality of their lamp is the whiteness, that is, similarity to sunlight, of the light produced. From this fact the discoverers have given it the name "Helion" (from a Greek word meaning the sun).

Simultaneously with the public announcement of this new and remarkable filament, a patent is issued from the United States Patent Office for a filament and a method of producing it, consisting of an alloy of tungsten with titanium and other metals. The date of the application of this patent, which has been taken out by Heany, shows that he was among the earliest experimenters in this line, being antedated only by Cazin.

The mention of the latter name also brings to our attention the fact that this well-known metallurgist utilized the so-called rare or infusible metals and their oxides in the production of lamp filaments a number of years ago, and sometime before any public announcement was made of filaments utilizing such material. Briefly stated, his method consists of electro-depositing any desired metal, such as osmium or tungsten, on to a carbon filament as a basis. The details have been quite fully described in two communications from Mr. Cazin, which have appeared in recent issues of THE ILLUMINATING ENGINEER. The simplicity of his method as compared with the methods described in recent patents for the production of rare metal filaments would seem to commend it to the attention of manufacturers.

That there are a considerable number of methods of arriving at the general result, namely, a filament which shall give an efficiency of three to four times that of the present carbon filament, is a matter upon which consumers may congratulate themselves, since it practically assures an open field in the manufacture of incandescent lamps.

IMPROVEMENTS IN THE MANUFACTURE OF INCANDESCENT GAS MANTLES

Recent improvements in the manufacture of incandescent lamp filaments have been so numerous and so revolutionary in character as to obscure the really important progress that is being made in the manufacture of incandescent gas mantles. The incandescent electric lamp was practically co-temporary with the incandescent gas light; each marked an era in the progress of illumination, and each had its own particular defect which handicapped its use. The incandescent electric lamp was comparatively inefficient as a light producer and correspondingly expensive to maintain, while the incandescent gas mantle was exceedingly fragile, thus entirely unfitting it for use in many positions, and occasioning more or less annoyance in others.

Experimenters in the two lines therefore had two main objects in view, namely, to increase the efficiency of the electric lamp filament, and the stability of the incandescent gas mantle. It is a rather curious coincidence that the solution of both problems has taken place simultaneously, and, as it were, by an exchange of methods.

As is well known, incandescent mantles have heretofore been made by impregnating a fabric knit from vegetable fibre with salts of the rare metals, and then burning out the vegetable matter. It will also be recalled that, for a number of years in its early history, the incandescent electric lamp filament was made by carbonizing natural vegetable or silk fibre. In fact, the only material improvement in the carbon filament lamp since its first introduction was the discovery of a practical method of preparing the filament material by dissolving the fibre

(cellulose) and drawing out the threads from the solution, thus producing fibres of practically uniform diameter and of solid, homogeneous structure.

It now appears that even greater advantages are obtained by the use of threads thus made in the manufacture of incandescent mantles. An exceedingly interesting and comprehensive article on the subject, contributed to the *Journal für Gasbeleuchtung* by Dr. Boëhm, of Berlin, will be found under the Review of the Technical Press, and will well repay reading for its general interest.

It appears that by the proper manipulation the mantles made of thread produced from a cellulose solution are not only far less fragile, but more efficient light producers as well; in fact, the two improvements together, while not revolutionary in character like the original discovery of the Welsbach mantle, are yet of sufficient importance to have a decided influence on the future of gas lighting.

Thus the incandescent electric lamp has taken a new lease of life by utilizing the more efficient light-producing properties of the "rare metals" and their oxides as exemplified in the Welsbach mantle, while the incandescent mantle is to be rehabilitated by appropriating the advantages of artificially prepared fibre, long used by its electrical competitor.

DIRECT vs INDIRECT ILLUMINATION

The revolution in the means of producing light electrically, which all authorities in this country now agree is imminent, is based upon the research and investigation of German and Austrian scientists and experimentors. A review of the technical literature of those countries also reveals the fact that the scientific basis of illuminating engineering is being investigated in the same painstaking and thorough manner that is such a well recognized characteristic of the Teuton mind.

Among the articles of the foreign technical press reviewed in this issue will be found one by Mr. E. Schilling, of Munich, in which there is a discussion of the relative merits of direct and indirect illumination. Careful tests were made of two different systems, one consisting of indirect illumination by incandescent gas lamps, the other direct illumination by incandescent electric lamps placed as high as possible, and using prismatic glass globes to direct and distribute the light. It appears that the indirect system by gas lighting seemed to be scoring an advantage from both the mechanical and hygienic standpoints over electric lighting, and this apparently stimulated the advocates of electric lighting towards efforts to devise a system which would surpass its competitor.

It is regrettable that this spirit of legitimate rivalry between the two systems of lighting, expressing itself in efforts of the contestants to surpass each other in the excellence of the general results obtained, has no adequate counterpart in this country; but as many of the great improvements in the production of light originated and flourished in Germany for some time before being generally recognized here, it is not too much to hope that the American gas interests will soon awake to the necessity of handling gas illumination from the scientific and engineering standpoint.

In regard to the hygienic quality of direct illumination from sources placed high, we cannot agree with the claims made by the German experimentors that the light is of equal hygienic quality with that diffused from a white ceiling. We contend, and we believe that experience will bear us out, that strong direct light, even from a prismatic globe, when reaching the eyes at a position high above them is exceedingly fatiguing.

There is also one important point in which indirect lighting from a white ceiling is defective, and that is in giving objects their proper relief, or perspective. This property is one of the

most important elements of vision, and in many classes of work, such for example as work on textiles, and fine mechanical work, the absence of relief produced by light coming equally from nearly all directions is a serious defect. The fact that indirect illumination simulates daylight to a certain extent must not be made too much of. As a matter of fact it does simulate daylight, but in a sky-lighted room; and if any one will undertake to do work under such a light, that is, daylight, through a ceiling, he will find that it is extremely annoying and fatiguing to the eyes. This is the case even though vision in which relief is of minimum consequence, such as bookkeeping or reading, be employed.

Being a new science, there is a natural tendency to jump at conclusions in regard to illumination, and some of the effects which are admirable from the theoretical standpoint will not stand the test of continual and actual use.

THE PURCHASE OF STREET ILLUMINATION

An item of "miscellaneous news" which appeared in our December issue is worthy of more than passing mention, as it calls attention to the extremely loose methods which have heretofore prevailed, and are still in common use in the purchase of street illumination by municipalities. It seems that the city of East Orange, N. J., or at least a portion of its citizens, lately became seriously interested in the economic problem involved in its public lighting. An illuminating engineer was employed by the City Council to investigate the matter and report. To the "surprise and indignation" of those interested, the report showed that the city was only getting about one-half the illumination which it was supposed to be getting, or at least entitled to, under its contract with the corporation furnishing the lights. Gas lamps which were supposed to furnish 50 candle-power, by an actual test in the streets only showed 22 candle-power. The responsibility for this state of affairs was clearly put up to the city authorities who made the contract, by the engineer making the report, who pointed out that the contract "failed to cover the very important considerations which would permit the company supplying the light to furnish inferior illumination without violating its contract and probably without fear of detection." In other words, the contract was a simple jug-handled affair, drawn by a corporation that fully understood its business and points of vantage, and entered into with city officials who knew nothing of the technicalities involved, and who did not recognize their ignorance sufficiently to employ an expert adviser. The calling in of an expert long after the contract had been made is a beautiful example of "locking the barn after the horse is stolen."

What would be thought of the business sagacity of a person who would make an important contract, involving both technical and legal matters of the highest importance, in which the other party were represented by expert counsel, without having any legal advice himself? And yet contracts involving millions of dollars for public lighting are annually made by public officials who know practically nothing of the technicalities of the subject, with corporations whose particular business it is to understand the matter in every detail. The examination of such contracts by a competent illuminating engineer is of far greater importance than their examination by the Corporation Counsel; and until cities realize this fact there is every occasion to blame, and little occasion to sympathize with them if they get the worst of the bargain in their dealings with the lighting companies.

HYGIENIC ILLUMINATION

Under the above caption the *Progressive Age* of January 1st contains a short and pithy editorial. The com-

ments made are so terse and to the point that they will bear repeating as topics for further discussion.

Beginning, the editor remarks:

The unfriendly have frequently contended that gas lighting was not healthful by reason of its vitiating the air of rooms, but they have yet to point out actual cases of positive injury resulting therefrom under normal conditions. The same cannot be said for electricity, for although the incandescent bulbs do not deliver carbon dioxide into the air, they injure the eyes for the benefit of which they are used instead of assisting them, by reason of both insufficient illumination and the blinding glare of exposed filaments burning their images into the retina of the eye until the nerves are seriously affected.

The question of vitiation of the air by the production of carbon dioxide from gas and oil flames is a very old one. Perhaps the most thorough investigations in regard to the matter were those, the results of which were embodied in a paper presented to the New England Association of Gas Engineers by Mr. A. P. Beardsley, which was reprinted in our May issue. In general it is safe to assert that this source of danger is much more theoretical than real; there is little reason to believe that the comparatively pure carbon dioxide generated in the process of combustion in the production of light ever assumes proportions that have any perceptible hygienic effect. It should be borne in mind that carbon dioxide chemically generated by the process of combustion is quite a different substance from the mixture of carbon dioxide with the various organic matter which is exhaled from the lungs in the process of breathing. Of the temporary discomfort, if not permanently injurious effects of the latter, when present in appreciable quantities, there can be no doubt; but of actual physical injury from the gas resulting from flames used for illumination, we have no knowledge of any authentic examples.

Proceeding, the editorial says:

The customer who buys electric light finds it expensive, tries to economize and the invariable result is insufficient light. To get the most for his money he places the light near the thing to be illuminated, right in the range of vision where the glowing filament is generally impressed on the less used portions of the retina and serious eye fatigue results. This would not be so reprehensible if the customer himself were the only one affected by this attempt at economy, but he subjects his family, his patrons or school children to an enforced torture, those who are defenseless against this insidious evil; eye strain results and often permanent injury.

That the conditions here set forth are only too common in actual practise must be admitted. It is hardly fair, however, to lay this sin of excessive glare (intrinsic brilliancy) entirely to the electrict light. Incandescent gas lighting has many sins of the same order to answer for. Ever since the electric lighting has been a commercial source of illumination the gas interests have been devoting themselves assiduously to an attempt to equal or surpass the sinfulness of the electric light in this respect. Not satisfied with the glare of a single mantle burner, they bunch three or four of them together in a vain attempt to outglare even the electric arc which, however, thus far stands unrivaled. As to the position of the light's source, the electric light has the advantage of being far more adaptable than gas, for the reason that gas must be within reach for turning off and on.

It is somewhat peculiar, and we think unfortunate, that the gas interests have not seized upon the inherent advantages of the incandescent gas light in having a somewhat lower intrinsic brilliancy than the incandescent electric lamp, together with the possibility of using diffusing globes without reducing the life of the incandescent body, as happens in the case of frosting the bulbs of electric lamps. We have already pointed out that the incandescent gas light in its present forms is incapable of quite as artistic treatment for most purposes, and especially for domestic lighting, as the electric light, and that, especially in view of the great reduction in cost of electric lighting which must soon take place by reason of improved forms of

lamps, it behooves the gas interests to make the most of the advantages of better diffusion, and lower intrinsic brilliancy, instead of resting wholly upon the mere superiority in the matter of cost. In this respect gas lighting fares better at the present time in Europe than in this country.

Proceeding, the editor says:

If there is anything we need more than another it is our eyesight and a direct and strenuous attempt should be made by all interested in the lighting business to make the eye the first and only consideration in designing lighting installations. By avoiding sharp contrasts, making general illumination soft and uniform, keeping all intensely bright lights out of the line of vision and deriving local lighting from large lighting surfaces, much can be accomplished, but the subject should be thoroughly investigated at once and lighting rules adopted and put in force.

This is a subject for the Illuminating Engineering Society to handle. They have been running to electricity very largely and it is to them we look for electric-lighting policy. They could readily compile a set of lighting rules and see that these get into the hands of all lighting companies for consideration, revision or adoption. Carbon dioxide has been present in rooms since the days of cave dwellers and we can put up with it a little longer, but these intensely glaring light sources are so recent as to have their evil affects not generally understood and this is all the mose reason that immediate attention should be paid to them.

It is impossible to lay too much stress upon the preservation of the eyesight, and the utter disregard of the dictates of the most ordinary common sense, to say nothing of the principles of illuminating engineering, which is so frequently in evidence in the very places where good illumination is most necessary—for example in school rooms, libraries, reading rooms, and work shops—is an outrage upon the most precious of all the senses which has absolutely no parallel in any other of the departments of practical hygiene. It is professedly one of the objects of the Illuminating Engineering Society to remove these conditions by calling attention to their existence, and disseminating knowledge which will lead to better methods of practise. While illuminating engineering may be truthfully said to have established itself as a profession, its field at present may be still considered as missionary ground, and a vast amount of work has yet to be done before the public in general have a due appreciation of the unnecessary inconvenience and injury which they have been enduring in this respect, and the ease with which these conditions can be improved.

THE FIRST YEAR OF THE ILLUMINATING ENGINEERING SOCIETY

With the annual meeting held on the 14th of this month, the Illuminating Engineering Society closed the first year of its official life. The report of the retiring president, Mr. L. B. Marks, and the brief address of the incoming president, Dr. C. H. Sharp, will be found elsewhere in this issue. President Marks' brief report covers the progress of the Society during its first year of existence. It is doubtful if any scientific or technical association has ever been organized which has accomplished so much in establishing its right to existence within a similar time as has been shown by the Illuminating Engineering Society. While there were at the beginning of the movement a few faintly dissenting voices, they were soon entirely lost in the general acclaim of approval with which its organization was greeted. The fact is that the time was not only ripe for illuminating engineering to come forth as a justly recognized branch of applied science, but conditions had actually been awaiting its arrival for a number of years. The seed thus fell on soil ready prepared and fertile for its growth.

The success of the first year is the best evidence of a continued and prolonged future.

Research and Investigation

CONDUCTED BY THE ILLUMINATING ENGINEER

[*NOTE.—It is the purpose of The Illuminating Engineer to supply to the fullest extent possible, original data pertaining to the engineering of illumination. To this end special investigations will be made from time to time by competent and impartial authorities, under our general direction, of matters upon which such research may promise new and valuable information. These investigations, of which several have already been made and reported in our columns, will be undertaken solely on our own initiative, and absolutely independent of any particular commercial interest. The actual laboratory work required will be carried out by competent and impartial investigators, and the reports made will be the exclusive copyrighted property of this publication.*]

THE INFLUENCE OF CHIMNEYS UPON THE EFFICIENCY AND PERFORMANCE OF INCANDESCENT GAS BURNERS

The introduction of airhole glassware, i. e., of chimneys having perforations near the bottom, for use on incandescent lamps, has been generally accepted in this country, as a distinct improvement, upon the claims that were originally made for this design on their first appearance in Europe. As these chimneys are radically different in their construction from the types formerly in use, and since, moreover, they differ among themselves in general design, it was thought that an investigation of the influence of the chimney on the performance of the burner might develop some interesting, if not important results. We accordingly purchased in the open market five different forms of chimneys, which practically represent all the different types now in common use. These include the long and short straight-sided chimney without perforations, and three different forms of perforated chimneys, as shown in the diagram, Fig. 1. These were submitted to the Electrical Testing Laboratories, and the results obtained are given in the following report:

Report on Photometric Test of Welsbach Lamp with Various Chimneys Submitted by and Tested for the Illuminating Engineering Publishing Co.

DESCRIPTION.

Welsbach Gallery Burner, catalogue No. 66, with No. 66 deck plate.

No. 197–J mantles (new).

Clear glass chimneys of the "F. Q. M." brand, as follows:

Fig. No.	Style	Height	Max. Diam.
1	Plain	5 7/8 in.	1 15/16 in.
2	"	8 "	1 15/16 "
3	Airhole	5 1/4 in.	2 1/4 "
4	"	6 3/4 "	2 3/8 "
5	"	9 7/8 "	2 7/8 "

METHOD OF TEST.

The photometric test was confined to the measurement of horizontal candle-power. Gas was obtained from street mains at a pressure of 1.5 inches water. With each chimney measurements were made with various adjustments of the gas flow, ranging from the smallest supply of gas which would render the mantle fairly incandescent up to the maximum supply of gas.

RESULTS OF TESTS.

The curves in Fig. 2 show diagrammatically the candle-power and candle-power per cubic foot per hour of the lamp submitted

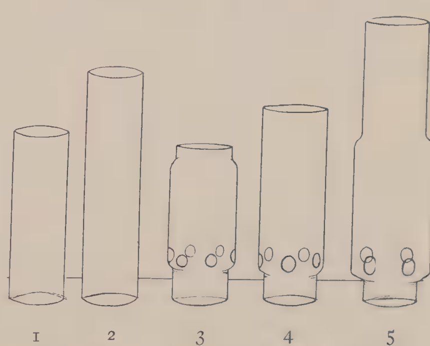


FIG. 1.—TYPES OF CHIMNEYS TESTED

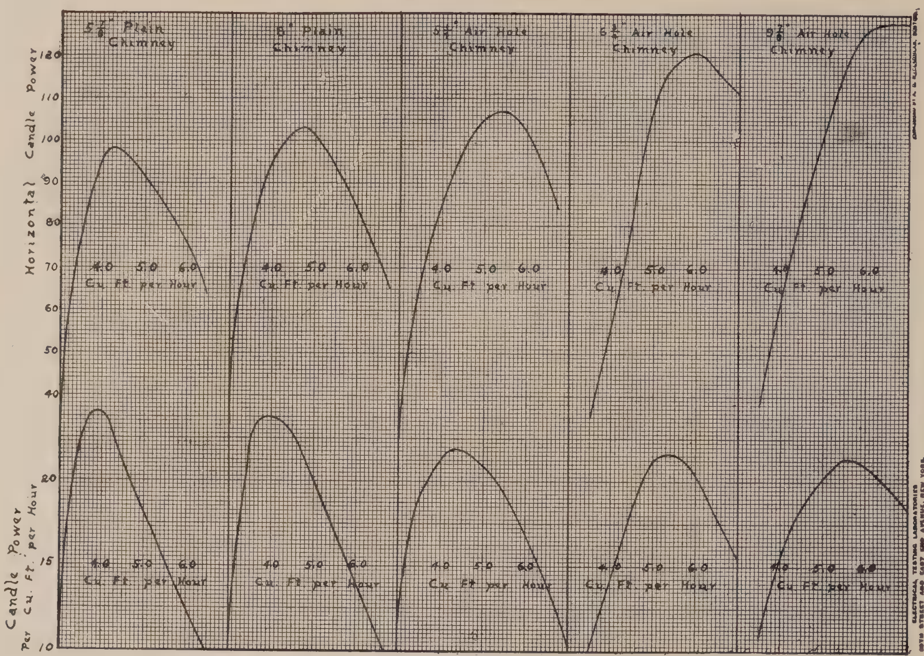


FIG. 2.—RESULTS OF VARIOUS CHIMNEYS ON CANDLE-POWER.

to test when equipped with each of the five chimneys, and when consuming gas at various rates supplied at a pressure of 1.5 inches water.

The maximum candle-power values and the maximum efficiences (expressed in candle-power per cubic foot per hour) which were obtained, appear in the table below.

From this table it will be noted that the maximum candle-power is obtained at a rate of consumption greater than that at which the maximum efficiency is secured. It also appears that the maximum candle-power and the maximum efficiency with the airhole chimneys are obtained at a higher rate of gas consumption than when the plain chimneys are used. Furthermore, with increased height of chimneys a higher rate of gas consumption is necessary to secure the highest obtainable candle-power and efficiency. In order to illustrate these points the curves shown in Fig. 3 have been prepared.

SIGNIFICANCE OF RESULTS.

The candle-power of an incandescent gas lamp depends upon a number of variable factors, among which the following are of first importance. A change in any

MAXIMUM CANDLE-POWER AND EFFICIENCY VALUES UNDER CONDITIONS STATED ABOVE

Chimneys	Maximum Candle-power. C. P.	Cu. ft. per Hr.	C. P. per Cu. Ft. per hour.	Max. Efficiency C. P. per Cu. Ft. per hour.
5⅞ in. plain	98	4.25	23.0	24.0
8 in. plain	103	4.75	21.7	23.7
5¼ in. airhole with deck plate	107	5.45	19.6	21.9
6¾ in. airhole with deck plate	121	5.95	20.3	21.5
9⅞ in. airhole with deck plate	128	6.75	19.0	21.3

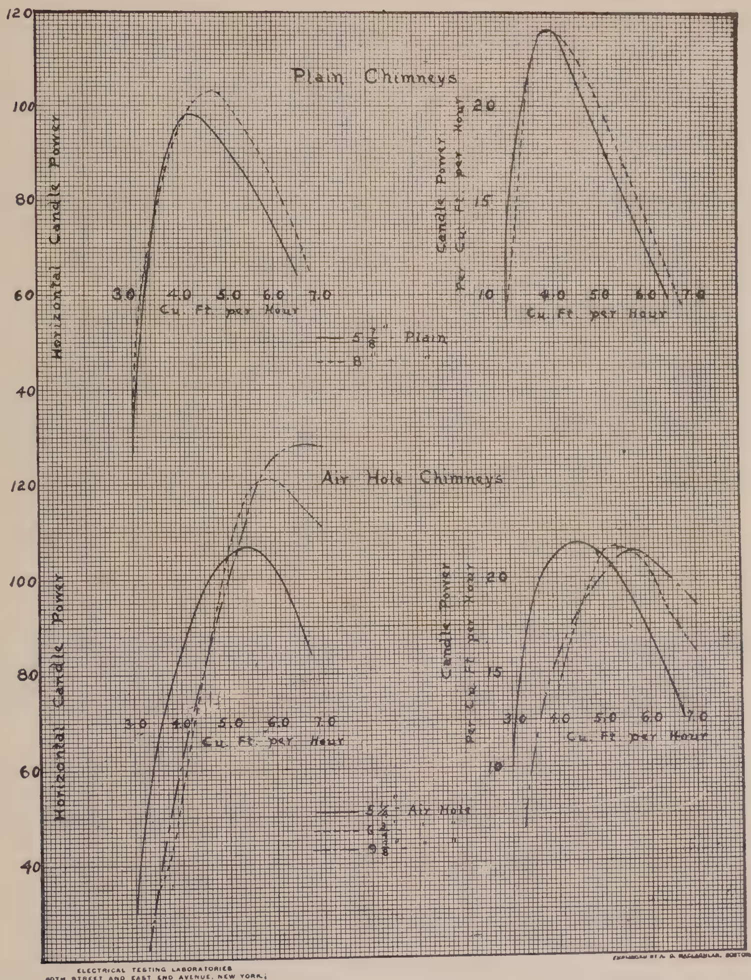


FIG. 3.—CURVES OF EFFICIENCY WITH DIFFERENT CHIMNEYS.

one of these might affect the results materially:

Gas Pressure.
Mantle.
Age of Mantle.
Burner.
Quality of Gas.
Atmospheric Conditions.

The significance of this test is therefore to be considered subject to limitations imposed by a single set of conditions.

ELECTRICAL TESTING LABORATORIES,
PRFSTON S. MILLAR.

Approved by Clayton H. Sharp, Test Officer.

P. S. M. — P.
Jan. 14th, 1907.

In general, the results of this investigation show that the commonly accepted opinions in regard to the relative merits of chimneys for incandescent gas burners are in exactly the reverse order of the facts. Thus, the greatest quantity of light from a given quality of gas, i. e., the greatest number of candle-power-hours per cubic foot, is obtained by the use of the plain, short, straight chimney, while the tallest air-hole chimney gives the smallest amount—about 16 per cent less; and this holds true whether the chimneys are adjusted to maximum candle-power or maximum efficiency.

The results shown develop some rather curious and interesting facts. Perhaps the most important of these is, that the highest efficiency of an incandescent gas burner in any case is not obtained under the conditions at which it gives its maximum quantity of light. This is especially true in the case of plain chimneys. The practise of adjusting a burner to give its maximum light, therefore invariably causes it to operate considerably below its maximum efficiency.

The curves in Fig. 2 bring out the rather curious fact that, while the maximum *candle-power* obtainable increases with the height of the chimney, as shown by the peaks of the curves in the upper part of the diagram, the maximum *efficiency* decreases in approximately the same proportion, as shown by the peaks of the curves in the lower part of the same diagram.

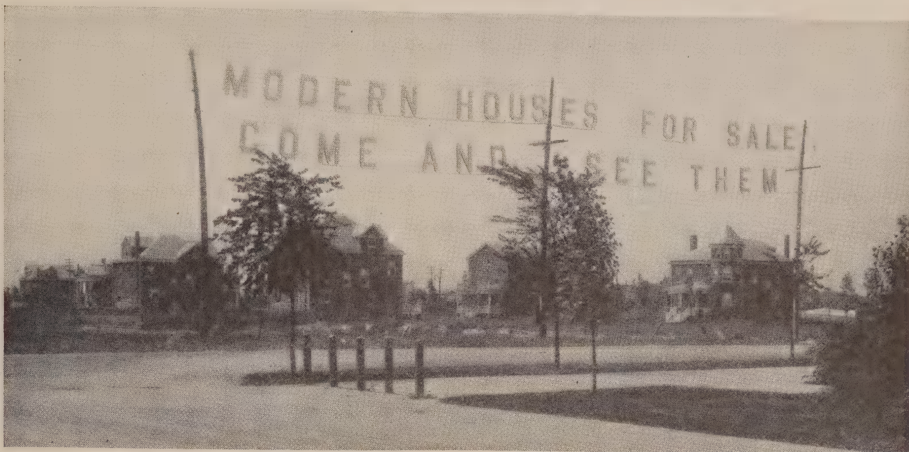
Another fact of importance, as brought out by this investigation, is that a greater total quantity of light can be produced with a given consumption of gas by the use of the straight-sided than with airhole chimneys; but such a result requires the use of a somewhat larger number of burners.

As we have mentioned before, the air-hole chimney is a German invention, and by far the larger part of the chimneys in use in this country of this pattern are still imported. They were hailed as a great improvement in incandescent lighting on their first appearance in Germany, and apparently have been accepted in this country without question, on their foreign reputation; and it will no doubt be a considerable surprise to those interested to find that these supposed improvements are in fact inferior to the little straight-sided chimney which has been almost entirely superceded by these newer forms. In seeking to produce a larger total candle-power, the question of actual efficiency has apparently been lost sight of. The fact that these air-hole chimneys are difficult, and therefore relatively expensive, to manufacture—so difficult in fact that, with perhaps one exception, they have not been successfully manufactured in this country—should lead manufacturers to further investigations as to the best form of chimney for modern burners; for it is evident that there is still room for material advancement along this line.

It will be noted that all photometer measurements in this investigation were made at a gas pressure of 1.5 inches of water, which may be considered nearly a minimum. It is possible that higher pressures may develop different results, and a further series of investigations is being carried out to determine this.

The question of the relative life of the different forms of chimneys is also of importance in connection with their use, but this is a matter upon which only extended observations would furnish any reliable data.

Facts and Fancies



CHICAGO REAL ESTATE ENTERPRISE

Chicago real estate dealers do not believe in sitting on the curb and waiting for customers to hunt them up. They put up their signs so that he who runs may read, by night as well as by day, as is shown in the above illustration. Where is the city that can beat this for "push"?

DON'TS IN ELECTRIC LIGHTING

In a letter appearing in the Chicago *Daily News,* signed by Ernest Filer, the following advice is given to users of the electric light:

Don't let the office boy or any one else who does not understand make changes in electric wiring or lights. They may do the very thing they ought not.

Don't pull a lamp hung by a flexible cord to one side with a wire and then fasten to a gas pipe. I have seen a wire become red hot in this manner. If the lamp hung by a cord must be pulled over, use a string.

Don't wrap paper around a lamp for a shade. You might go home and forget it and a fire might be started from the heat. Use a glass or metal shade. That is what they are for.

Don't let a socket on a fixture hang loose. Have it repaired. Otherwise it may cause trouble where least expected.

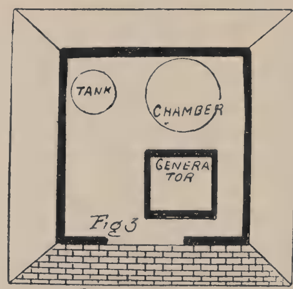
Don't try to save a little by running flexible wires over boxes, partitions, and into closets. Have permanent wires installed. These flexible wires used this way are dangerous.

HAVANA: A CITY OF LIGHTS

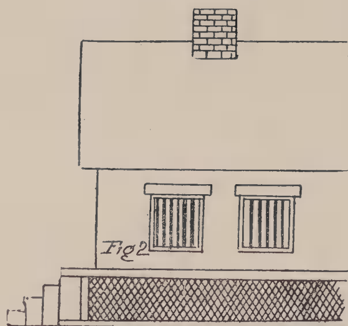
From *American Gas Light Journal.*

This is the land in which everybody burns numerous lights. Lights are in operation in lower floors, middle floors and upper floors of practically all dwellings. There are lights in the cupalos and lights on the porches; lights are burned all night at the gates. In fact, one might well call the city of Havana and suburbs a city of lights. I wondered how the people could afford to burn the gas and electric lights so freely, until I found out that several descriptions of light are used to keep down expenses. Carbide is procured here in 100-pound casks for $4.50, American money, at retail. You would be surprised on seeing the number of acetylene gas plants in operation in the Havana homes. It seemed to me that every dwelling, as well as nearly all buildings for business purposes, is furnished with exterior structures in which carbide gas is generated for the supplying of light; and some of these exterior structures are really attractive little buildings. The attached illustrations were sketched from some of the carbide houses. The people of Cuba take to the acetylene light with great freedom. Your correspondent, who has traveled in the Philippines, China, Japan, Hawaii and other countries, observed that carbide generators were used in some degree for the making of lights for homes and business houses; but the proportion of carbide consumed in Cuba is many times greater. It seems to be the fad to have an acetylene gas plant in connection with the other light equipments of the building.

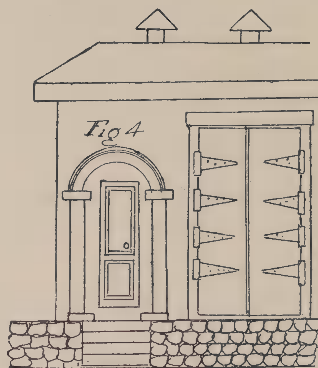
Fig 1.



FLOOR PLAN



LOOKS LIKE A HOUSE.



ACETYLENE GAS STRONGHOLD.

Some homes and business houses use four styles of light, namely, gas light, electrical light, carbide gas lights and oil lights. It is very usual to find the acetylene light in service with the electrical jets. Often the common house gas lights and carbide gas lights are combined in furnishing brilliancy for the Spanish or Cuban home. The foreigner who comes to the Islands quickly adopts the same method and has his installation of carbide gas made for permanent use. The United States army is here now, and where the troops are located at Camp Columbia, 9 miles out of Havana, a number of carbide gas generators are being introduced for lighting purposes. I find there are several reasons for the use of the carbide gas in this country. The leading one, of course, is the great desire of the people for plenty of light, who like to have a light shining in every room, whether the room is used or not. The people delight in entertainment and music on the porches of an evening, and numerous lights are required to make the scene right. If the people were to use electrical lights, or even the house gas at prevailing rates, for purposes of lighting as a Cuban mansion ought to be lighted, the cost would be high. Therefore the cheaper lights are sought out. At present the carbide gas is in favor, and numerous exterior structures are in course of building for the installation of gas making plants at the back of residences and business houses. If the people of the United States were to burn lights with the same liberality that the people of Havana do, the gas companies of America would reap a harvest.

The Cuban may economize on food and clothes, but he will pay out money liberally for lights and flowers. He does not overlook music, either. Lights, flowers and music are his choices. It is really worth the while to take a car ride through the city of Havana and the suburbs of Vendado and Marianoa for the purpose of observing the lighted porches and houses. The first light is at the gate of entrance; the next series is at the porch, followed by one over the main door. Then come the house lights, and you get a picture which reminds you of a theatrical representation. Neatly dressed ladies and children are on the porches or in the rooms. There is music. Perhaps wines are served. The gentlemen are neatly dressed. There are no blinds or curtains, and you can see everything and everybody. It is a beautiful sight. You can count two or three, sometimes four, kinds of lights, and distinguish them by their brilliancy. This keeps up late. The Americans do some figuring on gas bills. The hours of the night are

counted at so much per hour for gas expended; but the people of this country appear to overlook gas bills. They let the bills run on. They are inclined to sleep an hour or two in the afternoon, consequently they are rested for a night's entertainment. Therefore, to ride through the streets of the city and the suburbs at midnight means that you will find the lights brilliantly glowing in the homes. Soon after midnight things quiet down. The lights are extinguished and the shutters are closed, the iron gratings are clasped and the exterior of the house is gloomy indeed.

Meanwhile the meters have been clicking merrily along, and really quite a little item of gas and electrical light bill has been run up during the long evening. But nobody cares. The cost is kept down to some extent by the use of acetylene lights. And the Spanish and the Cuban folks are not satisfied with crude underground arrangements for the making of the gas. They do not use a basement, because as a rule no basements are made in these homes. They erect separate little edifices for the gas outfit. Everything connected with the generation of the gas is kept in this building. I have seen these structures erected with great care in conspicuous places in the grounds. The little things are well designed and finished. Fig. 1 will give an idea of one of the fanciful types of buildings used. The structure is made just about large enough so that a person can readily stand and move about inside, after the equipment for generating the gas is installed. The exterior is finished off to harmonize with the plan and color of the main buildings. The gas house is a part of the estate, just as in America we often see a dog house built to harmonize in shape and color with the residence or the barn. Sometimes the gas house is built like a living house, as in Fig. 2, and is divided off into rooms so that the servants may live there and look out for the plant. There are not many of the combination structures, however, because as a rule it is considered safer to have the plant in a building of its own. Fig. 3 is a diagram showing the floor plan of one of the typical gas houses.

Fig. 4 is a sketching of one of the large sized buildings, used for maintaining a big outfit for furnishing a public building with gas. All of these buildings are erected with a view of being exceedingly strong. Bolts and screws are employed freely. Some of the little structures are entirely of stone; others are brick and wood; some are covered with sheet metal.

The people quickly become familiar with the use of the carbide, and I have not heard of any accidents, although thousands of the equipments are in nightly service.

"FIRE-FLY" WATER DANCES IN BERLIN

Lamplight dances in the water form a brilliantly picturesque feature of the festival of the Berlin Swimming Club. Each swimmer, men and women alike, adorns his head with a lighted Chinese lantern; the merry crowd then swim in procession from the bath house, and at a signal from their commander perform various evolutions, the figures being, as it were, outlined in fire upon the waters. Large numbers of people delight in the spectacle, and the wonderful effects produced display considerable skill on the part of the performers.—*Popular Mechanics.*

Correspondence

FROM OUR READERS

CORRECTIONS

We are requested by Mr. Cazin to make the following corrections in his letters which appeared in the November and December issues:

Subsitute on page 742 the 2d line of the 4th paragraph by: "the basis of possessing originally" and cancel the last word "of" in the next line.

Cancel on page 845 in the 4th line of the 2d paragraph the word "begun."

Insert on same page 845 into the 8th line of the same paragraph, after "liberty of" the words "at present and until the patent, covering the new hermetical seal has been issued."

Substitute on page 846 the last word "street" of the 3d paragraph by the word: "dwellings."

Substitute on same page 846 the last two lines of the paragraph beginning with "3," by the words: "mounted on an inverted glass—(test-) tube."

Correct on page 847 in the 2d paragraph in the 6th line from its end the date of Cazin's Application to read: October 15, "1897."

Editor, The Illuminating Engineer.

Dear Sir:—

I find in the *Literary Digest* of Jan. 5 an article on "Cloud-Heights Measured by Electric Light," said to be from your publication. It states that the idea of determining by reflection the elevation of clouds, their bases of course, was never conceived of before.

I wish to state that I have known of this method for over thirty years, applying it myself first on Aug. 21, 1874. About 3 o'clock A. M. of that date a thunderstorm passed over this section and immediately after its passage, I noticed an illumination of the base of the storm-cloud or rather the outskirts of it. I was at the time much interested in storms, being an observer and correspondent of the Smithsonian Institution at Washington. Suddenly it occurred to me that I could determine the elevation of the cloud-base provided I could learn where the fire was. A local paper furnished in a day or two the desired data, stating that the barn of Andrew Lockhart was burned by lightning at the hour specified. I determined on the county map the distance from my point of observation to the Lockhart place. Having at the time of the fire taken the elevation of the central point of the glow upon level, I now had all the desired data and readily determined the elevation of the cloud-base.

In teaching classes, I have often mentioned this circumstance, and have spoken of it also in lectures in meteorology, but I am not sure that I have ever put the matter in print.

Yours truly,

S. A. MAXWELL.

Morrison, Ill., Jan. 12.

The Illuminating Engineer.

Gentlemen:—

The recent remarkable growth of interest in the subject of illumination is well exemplified by the rapidity with which the movement throughout the country has spread. Naturally at the start the subject of better illumination was taken up in the large cities but the smaller places have in many instances not at all been behind the larger places in the endeavor to give the customer better illumination and therefore better satisfaction for the same expenditure of energy. So rapid has been this growth that the Lamp Companies find it impossible to fill the orders for the latest types of lamps of a higher efficiency than the old carbon types. As an example as to showing how the movement has spread to the smaller towns may be cited the case of Middlebury, Vermont, a small place of only 1,900 people. This town, under the efficient management of Mr. C. C. Wells, Secretary and Manager of the Company, has perhaps some of the best lighted stores that can be shown anywhere. The store lighting of

this small place is on the average much superior to the larger cities. The movement is spreading so rapidly in the town that the management find it impossible to keep pace with the same.

It is interesting to note the attitude of a small place like this compared with the attitude of similar towns a few years ago before the movement toward better illumination had started. At that time a store was sufficiently well lighted if a number of bare incandescent lamps were hung by drop cords in different parts of the store, allowing the bare lamps to glare in the eye of the customer as they were placed only slightly above his head; lighting the ceiling fully as well as the counter. Today this attitude has materially changed and the electric light companies are endeavoring to educate their customers to the difference between light and illumination which results so materially to their benefit as the customer ultimately uses more light, gets better illumination and becomes a satisfied instead of a dissatisfied customer.

Very truly yours

V. R. LANSINGH.

New York City, January 11th, 1907.

Editor, The Illuminating Engineer.

DEAR SIR: Will you kindly print in your journal definitions of the terms "Lux" and "Lumen," and make comparisons, if such be possible, with candle-power.

I think it would be a good plan to insert a glossary of all technical terms for the benefit of those who, like myself, are on the threshold of this science, and have a partial idea, for instance, of what Fechner's law is.

Yours truly,

R. LOUIS LLOYD.

The term "Lux" has at least as many different values as there are different important countries. The original suggestion of the term is attributed to Preece, who in 1883 defined it as the illumination on a surface normal to the rays, and 12.7 inches from the standard English candle; and this definition is given in the American dictionaries.

Palaz (Industrial Photometry) gives it as the illumination produced by a source having an intensity of one decimal candle (equal to 1/20 of the absolute platinum standard) at a distance of one meter.

Louis Bell defines it as the Bougie-meter of intensity; the Bougie being the French standard candle.

Carl Hering states that the lux is equivalent to a Hefner meter, the Hefner being the German standard candle.

Lastly, Flemming gives it as the intensity produced on a surface at one meter distance from a light-source giving unit intensity, leaving the standard light-source to be supplied according to the custom of the country in which measurements are made.

From these definitions it will be seen that the term "Lux" at present has absolutely no fixed meaning, unless it is specifically defined.

The "Lumen" is a unit intended for the measurement of the total quantity, or flux, of light given out by a source. The relative total quantities of light given out by different sources are in proportion to their mean spherical candle-powers, although in a stricter sense mean spherical candle-power is a measure denoting intensity of illumination on a unit surface. The lumen is intended to express the entire flux of light, and is derived by multiplying the mean spherical candle-power, or intensity by 4π.

The process is equivalent to finding the surface of a sphere from the radius.

The Illuminating Engineering Society

THE FIRST ANNUAL MEETING, HELD IN NEW YORK, JANUARY 14TH

CLAYTON H. SHARP.
PRESIDENT OF THE ILLUMINATING ENGINEERING SOCIETY.

The first annual meeting of the Illuminating Engineering Society was held in the rooms of the Electric Club, 14 Park Place.

Before proceeding with the regular order of business a banquet was spread in the rooms of the Club, at which the general spirit of good fellowship and enthusiasm in the interests of the Society and its objects which has characterized the movement from its inception, prevailed.

In accordance with the broad, democratic lines upon which the association was formed, the banquet was wholly informal and of modest prententions, points which increased rather than lessened the enjoyment of those present.

At the conclusion of the gastronomic preliminaries the meeting was called to order by President Marks, and the reports of the Secretary and Treasurer were duly presented and accepted. The Treasurer's report closed with the following statement, which should prove gratifying to the members: "The Society has passed through its first year with all its expenses paid, has equipped offices in the new United Engineering Building, has paid all bills, and is still solvent."

The Assistant Secretary then read a letter of regret from Thos. A. Edison, stating that, on account of a severe cold he would not be able to be present, and requesting that his name be presented for membership.

The next order of business was canvassing the votes for officers for the Society for the ensuing year. The report of the tellers showed the following candidates to have been elected:

President, Clayton H. Sharp.

Vice-President, Louis Bell.

Managers, E. L. Elliott, and J. E. Woodwell.

Secretary, V. R. Lansingh.

Treasurer, A. H. Elliott.

The vote on the adoption of a new constitution resulted in its adoption by 144 to 23. (The constitution and by-laws as adopted will be found on pages 958 to 962.)

While the tellers were canvassing the ballots for officers, President L. B. Marks presented a report, as follows:

REPORT OF PRESIDENT MARKS

At the request of the Council I have prepared a brief report of the work done since the date of organization of the Society just a year ago.

In reviewing our progress, it may not be amiss to pause for a moment and consider the conditions that prevailed from an engineering standpoint in the science of illumination before the organization of this Society. I think it will be generally admitted that while questions concerning the generation and distribution of electric current and of gas for lighting purposes received most careful attention, the problem of obtaining the best illuminating result from the electricity or gas produced was neglected. The wasteful methods that have prevailed in the distribution of illumination need no comment by me. The injury that has been wrought on our eyesight by improper lighting layouts is a matter of common knowledge.

The Society, in endeavoring to place the art on a new basis, has collected and placed on record much available information relating to this field of engineering. It has brought together to discuss these questions, electrical engineers, gas engineers, architects, designers of globes, reflec-

tors and fixtures, oculists, chemists, physicists, manufacturers of and dealers in lighting apparatus, appliances and material—in fact, representatives of almost every field of endeavor in which the question of illumination plays a part. By the co-operation of these various interests a start has been made in the collection and publication in the *Transactions* of invaluable papers, discussions and data which would otherwise be widely scattered and little accessible, and advances in the art have been inaugurated that would otherwise be practically impossible.

The Society has published and spread broadcast papers and discussion on illumination by electric light and by gas. Both indoor and outdoor illumination have been treated. We have heard the point of view of the architect and have considered the physiological side of the question. For the first time probably in history a meeting was held, at the instance of this Society, between oculists and illuminating engineers, for the purpose of discussing questions of artificial illumination.

We have studied what type of lamp, what size of light unit, what location and character of fixture and what kind of globe, shade or reflector, is best suited to meet the demands of individual conditions in lighting.

We have noted that in the course of the year many old installations of gas and electric light fixtures have been modernized, and that in many of the new installations the design and the equipment has been vastly improved from an illuminating standpoint. Central stations are now giving more attention to this subject than before, and in some cases are employing specialists to take charge of this important end of their work. Even the architect, who for years has held out firmly against the engineering side of illumination, is gradually succumbing to this wave of progress.

Perhaps one of the most important points that has been dwelt upon by the Society in its papers and discussions is the urgent need of reducing the intrinsic brightness of light sources, and particularly of such sources as are necessarily within the ordinary field of vision. Happily we have tangible evidence of improvements in this regard made during the past year.

The general acceptance of definite nomenclature and standards will be of immense service in furthering the systematization of illuminating engineering. At the present time our terminology is at best crude, and very often we are unable to avail ourselves of the benefits of valuable work done by others, because the terms used in published reports of such work are open to misinterpretation. To secure uniformity, the co-operation of the members of the lighting fraternity, not only of this country, but of foreign countries, is necessary. Much has already been done by committees to bring about the standardization desired.

I have pleasure in announcing this evening the appointment of the following international committee of the Society:

Committee on Nomenclature and Standards (Members of the Illuminating Engineering Society)

Dr. Alex. C. Humphreys, Chairman, Stevens Institute, Hoboken, N. J.

Dr. Louis Bell, Boston, Mass.

Prof. Blondel, Paris, France.

Dr. Hans, Bunte, Technische Hochschule, Carlsruhe, Germany.

Mr. John W. Howell, Harrison, N. J.

Dr. E. P. Hyde, Bureau of Standards, Washington, D. C.

Dr. A. E. Kennelly, Harvard University, Cambridge, Mass.

Prof. Vivian B. Lewes, Royal Naval College, Greenwich, Eng.

Dr. Edward L. Nichols, Cornell University, Ithaca, N. Y.

Dr. F. Schniewind, New York City.

Dr. C. H. Sharp, New York City.

Mr. W. D. Weaver, New York City.

Mr. J. E. Woodwell, Secretary, Washington, D. C.

At the date of writing, the total membership of the Society is 815. Twenty applications for membership have been received but have not yet been acted upon by the Council.

In the following table the membership is given for each month since the date of or-

ganization of the Society, on January 10, 1906:

Month.	Membership.	Increase.
January	89	...
February	192	103
March	272	80
April	386	114
May	478	92
June	553	75
July	572	19
August	581	9
September	581	0
October	618	73
November	709	91
December	815	106

It will be noted that the membership shows a healthy and a fairly uniform increase. During the summer months there was naturally a decided falling off. It is significant that the membership increased almost 50 per cent. during the last three months of the year.

The distribution of membership is as follows:

MEMBERSHIP.

California	9
Colorado	2
Connecticut	5
District of Columbia	4
Georgia	3
Idaho	1
Illinois	80
Indiana	3
Iowa	5
Louisiana	1
Maine	1
Maryland	7
Massachusetts	81
Michigan	6
Minnesota	8
Mississippi	1
Missouri	6
Nebraska	3
New Hampshire	1
New Jersey	37
New Mexico	2
New York	252
North Carolina	2
Ohio	21
Oregon	4
Pennsylvania	239
Rhode Island	3
Tennessee	1
Texas	4
Utah	2
Vermont	2
Virginia	1
Washington	3
West Virginia	1
Wisconsin	8
	809

FOREIGN MEMBERSHIP.

Austria	1	
Canada	7	
England	11	
France	5	
Germany	4	
Italy	1	
Japan	1	
Mexico	1	
South America	1	
West Indies	1	
		33
		842
Deducting exchange list of 27		27
Total membership to date		815

SECTIONS.

In order to distribute as equitably as possible the benefits and privileges of membership in the Society, the Council authorized the organization of sections in any city or locality in which the local membership is fifty or more.

A section was organized in Boston almost immediately after the first regular meeting of the Society in New York. Then followed the organization of sections in Chicago, Philadelphia and Pittsburg, respectively. Subsequently the membership in New York and vicinity was organized as a separate section, so that now we have five sections of the Society, all conducted on the same general plan and all receiving practically the same benefits of membership in the Society. Papers that are accepted for presentation before the Society are submitted to all of the sections for reading and discussion. The papers, together with the discussion thereon at the various sections, are printed in the following number of the *Transactions* of the Society and distributed to the membership at large.

In the early stages of our work the criticism was advanced that many were deprived of much of the benefit to be derived from membership, for the reason that only such members as resided in New York City and locality could attend the meetings and participate in the discussions. This criticism was met, to a large degree, by the organization of the sections, as above outlined. There is still need, however, for the organization of a few more sections,

particularly in the West and South. A glance at the distribution of membership of the Society will show that at present about 75 per cent. of the members reside in the eastern part of the country. With the organization of sections in the middle and far West, we may look for a large increase in the membership of the Society in that territory.

While each section is an independent unit having its own by-laws, board of managers and committees for conducting the local work, the regulation of the conduct of the sections is intrusted to the general Council of the Society. And this must necessarily be so in a national organization such as ours. Co-operation between the different sections is absolutely essential for the welfare and for the life of the Society. It is the purpose of the federal organization to vouchsafe for the Society, through the medium of its general officers and Council, the full benefits which can be derived only by such co-operation.

Each section may present such papers or communications as it sees fit before its members, but for the protection of the Society the Council exacts that no paper, discussion, communication or report shall be printed in the *Transactions* of the Society unless approved by the General Committee on Papers. It is, therefore, important that papers be submitted to the Committee as far in advance of their presentation as possible, in order to insure nearly simultaneous presentation before the several sections of the Society.

It should be borne in mind that a paper that may be suitable for presentation before a section may not be appropriate for the printed proceedings of the national organization. Moreover, the extent of the publication in the *Transactions* is necessarily limited by the exchequer of the Society. It goes without saying that the regulation of this matter must be left in the hands of the General Committee on Papers.

In order to facilitate the timely issue of the *Transactions,* the corrected transcript of discussions at meetings of the sections should be forwarded to the General Secretary as soon as possible after each meeting. One of the strong points in favor of this Society is that the membership throughout the country is kept advised, month by month, of the latest developments in the art, and is informed by discussions, through the medium of the *Transactions,* of the views of representatives of the various interests that have to do with illumination. It is therefore apparent that unless the sections co-operate to secure speedy publication of such discussions, the immediate value of the *Transactions* will be impaired. Under the plan of sectional organization the issue of the *Transactions* must necessarily be deferred until the reports of the local meetings are received by the General Committee. In one case during the past year the transcript of the discussion that took place at the sectional meeting was not received by the General Committee until almost six weeks after the date of the meeting, and the issue of the *Transactions* was, therefore, correspondingly held up.

Since the organization of the Society the New York Section has had nine meetings; the New England Section, seven; the Chicago Section, four; and the Pittsburg Section, three. The total attendance at New York for the past year was about 675, the minimum 40, the maximum 200, and the average about 75. No figures are at hand for the attendance at the other sections, but from reports received, the interest manifested in the meetings has been marked.

NEW CONSTITUTION.

With the changed conditions that have been brought about by the foundation of sections since the date of organization of the Society, the present Constitution is wholly inadequate for the proper government of the Society. When the present Constitution was drawn up we had a strictly local organization. Today we have a federal organization with local sections. The underlying idea of the new Constitution is to keep the federal organization intact. To accomplish this purpose the Constitution provides for the general government of the sections and clearly defines the relation of the local sections of the

federal body. It provides for the election of one Vice-President of the national organization for each section of the Society. The Vice-President will thus be a link between the local organization and the General Council of the Society, and, together with such Directors as may be elected from the locality of any Section, will represent that Section in the General Council.

Federal officers will be nominated by a Board of Nomination instead of by the membership at large, the Board of Nomination to consist of two junior Past Presidents and of a specific number of past Vice-Presidents representing all of the sections of the Society. The Constitution specifically provides that nominees for the office of Vice-President shall be so selected that, if such nominees are elected, each locality where there is a section of the Society may be represented in the Council by a Vice-President.

I think it will be conceded that this method of nomination will insure for the Society the selection of such candidates as are best qualified to fill the offices for which they are nominated. The Board of Nomination will necessarily consist of past officers of the Society, who are familiar with the requirements and who have every reason to act only in the best interests of the organization.

TRANSACTIONS.

During the year the *Transactions* have increased from a 40-page number to a 100-page number. Seven numbers have been issued containing nearly 400 pages of reading matter.

From the report of the Finance Committee, it will be seen that the expense of this publication has reached a point beyond which, with the annual dues of only $5, and present running expenses, we cannot well afford to go until the membership of the Society increases substantially.

To meet a possible deficit, the Council decided to set aside a limited number of pages in the rear of the *Transactions* for the insertion of advertising matter. The solicitation of advertisements was placed in the hands of an advertising agent, who has no official connection with the Society.

BADGE AND CERTIFICATE.

The Society Badge, designed by Mr. Waldo S. Kellogg, member, has been much admired. The Treasurer reports that almost 100 of the badges have been disposed of. The Council has authorized the issuance of a certificate of membership, the design for which will be submitted shortly.

NEW HEADQUARTERS.

The Council has authorized the lease of an office in the Engineering Societies' Building, New York City, for the general headquarters of the Society. This office will be opened within a few days, with Miss E. Westervelt, the Assistant Secretary, in charge.

OBITUARY.

It is my sad duty to report the death on November 21, 1906, of Mr. Alexander MacAndrew, who was a member of this Society. For the last six years he was connected with the lamp works of the General Electric Company, at Harrison, N. J.

CONCLUSION.

In conclusion, I wish to thank the officers and Council of the Society and of the Sections for the valuable assistance given to me in the work of the year. The manifold duties of the Society have in a large measure been intrusted to committees, the membership of some of which has found no place in the publications of the Society. To the members of these committees I would extend my thanks, and in particular to Mr. W. D. Weaver, who, as chairman of three committees, has indeed borne a heavy burden. The work of the Treasurer has extended far beyond the financial side of his position and merits special recognition, as does likewise that of Dr. Sharp, the chairman of the committee on papers. I looked to Dr. Elliott and Mr. Brown of the Council for advice with regard to the gas interests, and take this opportunity of thanking them for their valuable assistance.

On behalf of the Society, I desire to tender thanks to the New York Edison Company for the use of their auditorium

for a meeting room for the monthly meetings of the New York Section, and to the Consolidated Gas Company for the use of quarters in their building for the office of the Secretary. Our thanks are also due to the Electrical Club for their courtesy in placing their rooms at our disposal for the dinner and meeting of this evening.

To the technical press we are indebted for valuable co-operation and for the wide publicity given to our proceedings.

The new administration which is to be inaugurated this evening will have upon its shoulders a task by no means light. The past year has witnessed only the beginning of the movement to give to illuminating engineering a recognized status. The real work of placing the art of illuminating on a new basis and systematizing the practice of illuminating engineering is yet to be done and will require years to accomplish. To bring about the desired results, cordial co-operation between the Sections of this Society is a prerequisite. With the close relation between the General Council of the Society and governing body of the local sections, as contemplated by the new Constitution, nothing should stand in the way of such co-operation.

At the conclusion of the President's report, which was greeted with hearty applause, Mr. A. A. Pope said:

Gentlemen.—I imagine that the President is a little delicate about calling for a discussion of his report, so I will assume that duty. The paper is now open for discussion.

Mr. Lansingh said: "The only remark I would like to make on the paper is, that I have been a member of the Council, have been at most of the meetings, and thought I knew what was going on, but the President's report is an eye-opener to me. I think the Society owes a most hearty vote of thanks for the wonderful work he has done. Those members of the Council who have been with him in the work appreciate perhaps more than anybody else the tremendous amount of work he has accomplished and the time he has spent in the interest of the Society. I should like to move a vote of thanks to the President for what he has done."

The motion was seconded and unanimously carried.

Mr. Pope: "I see some of our friends from Philadelphia are with us tonight. Have you any remarks that you would like to make, or any suggestions for the benefit of the incoming President and fellow members of the Society?"

Mr. P. H. Barnard replied that in Philadelphia they naturally felt gratified by the result of the year's work, and that the hard work of the President and members of the Committee had made the Society a possibility. They had felt the need of such an organization in Philadelphia for a number of years, and held monthly meetings of an organization which, while it was not an illuminating engineering society by any means, was really started with that idea in view, in some measure, namely, of educating the solicitors of their company upon the subject of lighting. The organization of the society is of course a great assistance in that matter.

President Marks spoke of the necessity of having a section further west than Chicago, and Mr. Lansingh said he was very glad to state that during the coming year he thought a section would be formed in San Francisco. He had been in correspondence with different engineers there, and they thought that during the coming year they could organize a section. The fire had so wiped things out that at present they were unable to do it, although they are ripe for it as soon as they can get things organized.

Replying to an inquiry by Mr. E. Y. Porter in regard to the arrangements in the New United Engineering Societies Building, President Marks said that he believed that the lease of the office contemplates the use of the meeting hall for general meetings, and also the use of the general council hall if necessary. The office that the Society had rented was rather small, but was within the means of the Society, and it seemed to the members of the Council that it would be unwise to incur greater expense until the membership increased.

In response to calls from the members, the newly-elected President, Dr. Sharp, replied as follows: "I want to say that I appreciate very greatly the honor which you have done me in electing me as your second President; but I can't say that I thank you for it (laughter), because I realize that it involves a very gread deal of responsibility, which I very candidly say I do not feel myself fitted to bear. However, you have elected me, and I intend to do all that I can for the credit and for the welfare of the Society.

"I think this, that the coming year will be a critical one. We have had a surprising degree of success in the first year of our existence, a most remarkable degree of success. Now, if the ardor and enthusiasm which have been manifested during the year that has passed can be sustained during the year that is to come, the success of

the Society for many years will be assured; but if under the new order of things, after the new constitution which has just been adopted, and which represents in many respects a very radical change in the methods of conducting a national society, goes into effect—if we can make this new instrument operative, and if we can get the proper coöperation between the various local sections of the Society, it will make a permanent success; otherwise it will lapse, which will be most unfortunate.

"There is no doubt that we are working on a very live subject, and that the field that lies before us is a very large and important one. It would be a great pity if this Society, having had the splendid start which it has had, should not continue to flourish and to increase in membership and in influence; and this is largely a matter of our all pulling together and trying to make a success. Under the new constitution, as you will see, it is very largely a question of the handling of the local sections. It is not a question of what New York does, or Philadelphia does, or Pittsburg does, alone; it is a question of what all do, and how earnestly each section strives to make its own work successful and useful, not only to itself but to the Society at large; and if the sections will realize the responsibility and privileges in this matter, and will strive without animosities or jealousies (for which there is no place in an organization of this kind) to make their own work of as high a standard as possible, and to do as much as they can for the welfare of the Society at large, I am sure that our efforts will be crowned with success.

"I feel more encouraged to take this office from the fact that the arduous duties and great responsibilities which my predecessor has so successfully coped with, will not be mine. The office of President will be to a very considerable extent an ornamental office, and I trust I shall be able to develop its esthetic properties (laughter) in the fullest degree. Being an ornamental office and not so vital to the welfare of the Society, as I say, I feel more encouraged to accept and to do what I can in the matter; but I must ask and plead for the very earnest coöperation not only of the officers of the Society but of the individual members. It is necessary that the enthusiasm be sustained, the spirit of work be kept up; that the attendance upon meetings of the Society shall be kept large; that the members shall feel that there lies upon them an individual responsibility to come to the meetings and to try to make them successful, to contribute their quota to the success of the organization; and if that is done I am sure that we shall have a useful and successful year.

"So, gentlemen, I thank you for the honor which you have done me, which I esteem very highly indeed, and ask you to help the administration all you can individually and collectively to carry the work on during the year that is to come.

"The hour is growing late. I have a couple of announcements to make, and the meeting will then adjourn.

NEW CONSTITUTION OF THE ILLUMINATING ENGINEERING SOCIETY.

ARTICLE I.

1. The name of this Association shall be the Illuminating Engineering Society.

2. Its objects shall be the advancement of the theory and practise of illuminating engineering and the dissemination of knowledge relating thereto. Among the means to this end shall be meetings for the presentation and discussion of appropriate papers; the publication as may seem expedient of such papers, of discussions and communications; and through committees, the study of subjects relating to the science and art of illumination, and the publication of reports thereon.

ARTICLE II. MEMBERSHIP.

1. The members of this Society shall be designated as members and honorary members.

2. A member may be any one interested in the objects of the Society. At the time of his election he shall not be less than twenty-one years of age.

3. Honorary members may be chosen from among those who are of acknowledged eminence in some branch of science related to illuminating engineering. Honorary members shall be entitled to all the privileges of the Society except the right to vote and to hold office therein.

ARTICLE III. ADMISSION AND EXPULSION OF MEMBERS.

1. Honorary members shall be proposed in writing by at least fifteen members, and shall be elected only by the unanimous vote of the Council. Voting shall be by letter-ballot. A person elected an honorary member shall be promptly notified by letter, and the election shall be canceled if an acceptance is not received within six months after the mailing of such notice.

2. An application for admission to the Society shall be made in a form prescribed by the Council, and shall refer to at least two members of the Society; or if an applicant certifies that he is not personally known to two members, references may be accepted to members of professional societies of good standing, or to other persons whose good standing may be readily verified.

3. All applications for admission to

membership shall be passed upon by a Board of Examiners of the section of the Society representing the locality in which the applicant resides. All applications favorably considered shall be reported to the Council for final action. An applicant not residing within the territory of a local section shall submit his application direct to the Council.

4. Lists of all new applicants for admission shall be printed in the *Transactions*, together with the references of each applicant, and with the request that members transmit to the Council any information in their possession which may affect the disposition of the application. The Council shall not act upon any name until at least twenty days after the date of mailing of said list.

5. A member may resign from the Society by a written communication to the Secretary, which resignation shall be accepted by the Council if all his dues and other indebtedness have been paid, and the Society badge has been returned.

6. Upon the written request of ten or more members that for cause definitely stated in detail, a member of the Society be expelled, the Board of Managers of the section of the locality wherein the accused resides shall consider the matter, and if there appears to be sufficient cause shall advise the accused of the charges against him. The accused may then present a written defense and appear in person before a meeting of the Board. The finding of the Board shall then be submitted to the Council of the Society which, within two months, shall finally consider the case, and if a satisfactory defense has not been made the accused member shall be expelled upon a two-thirds vote of Council. In the case of one not a member of a section, charges shall be preferred directly to the Council.

ARTICLE IV. DUES.

1. An entrance fee, payable on admission to the Society, may be fixed by the Council.

2. The annual dues shall be $5, which shall include subscription to the *Transactions* of the Society.

3. Honorary members shall be exempt from all payments.

4. A member elected after six months of the fiscal year have expired shall pay one-half of the amount of dues for that year; provided, that if he requests and receives a set of *Transactions* covering the entire year, then the full annual dues shall be paid.

5. A member who has been dropped as delinquent may be reinstated by the Council and retain his original date of election upon payment of all back dues, being then entitled to a complete file of the publications of the Society, if in stock, corresponding to the period of delinquency.

ARTICLE V. OFFICERS.

1. The officers of the Society shall be a President; Vice-Presidents equal in number to the number of organized sections; nine Directors, a Secretary and a Treasurer.

2. The President, the Secretary and the Treasurer shall hold office for one year; the Vice-Presidents shall hold office for two years, and the Directors for three years. Terms of office shall commence the second Friday of January. A retiring President, Vice-President or Director shall not be eligible for immediate re-election to the same office, and a retiring Vice-President shall not be eligible for immediate election as Director. At each annual meeting officers shall be elected to succeed those retiring by expiration of term.

3. A vacancy in the office of President shall be filled by the senior Vice-President; a vacancy in the office of Vice-President shall be filled by the senior Director; a vacancy in the office of Director shall be filled by the Council, preferably by selection from members, if any, who at the previous annual election received votes for the office of Director. A vacancy in the office of Secretary or Treasurer shall be filled by the Council. Such succession to office or appointment by the Council shall not render an officer ineligible for immediate election to the same office. Seniority between officers of the same rank and date of election shall be determined by the date of their election as members.

4. No officer shall receive, directly or indirectly, any salary, compensation or emolument from the Society, either as such officer or in any other capacity, unless authorized by a vote of the majority of the entire Council. No officer shall be interested, directly or indirectly, in any contract relating to the operations conducted by the Society, nor in any contract for furnishing supplies thereto, unless by the unanimous vote of the Council.

ARTICLE VI. ELECTION OF OFFICERS.

1. Each year not later than November 1 a Board of Nomination, consisting of the two junior Past-Presidents and of the Past-Vice-Presidents whose terms of office expired in January of the two preceding years, shall prepare a nomination ticket containing the names of those whom they deem best suited for the offices to be filled at the ensuing annual election. Nominees for the office of Vice-President shall be so selected that, if such nominees are elected, each locality where there is a section of the Society may be represented in the Council by a Vice-President.

2. The ticket thus prepared shall be

printed and forwarded to members not later than December 5, together with a printed Roll of Members of the Society, an unmarked inner envelope, and an outer official voting envelope bearing the name and address of the Society and the words, "Official Voting Envelope—Enclosing a Ballot Only." The member voting shall enclose his ballot in the unmarked envelope, which shall, in turn, be enclosed in the outer envelope, which latter shall be endorsed with the name of the sender. Ballots to be counted must reach the Secretary not later than December 26.

3. A member may vote the official ballot above provided for; or he may erase any names thereon and substitute others; or he may substitute a written ballot containing names of his own selection.

4. The President at a Council meeting in December shall appoint, subject to the approval of the Council, five members not members of the Council, to constitute a Committee of Tellers. This Committee shall meet between December 26 and December 30, and shall receive unopened all ballots from the Secretary and shall forthwith proceed in secret to count the vote. It shall then prepare in duplicate and sign a report of the results of the vote, which shall be sealed, and one copy delivered to the Secretary and the other handed by the chairman of the Committee, at the ensuing annual meeting, to the presiding officer, who shall at the opening session of the meeting break the seal and announce the names of the officers elected.

ARTICLE VII. MANAGEMENT.

1. The affairs of the Society shall be managed by a Council under this Constitution and under the By-Laws adopted for the execution thereof. The Council shall direct the business of the Society either itself or through its officers and committees.

2. The Council shall consist of the officers of the Society and of the two junior Past-Presidents.

3. The Council may delegate any or all of its powers to an Executive Committee of five members, consisting of the President, the Secretary and the Treasurer, ex-officio, and two other members of the Council, which Committee shall conduct the affairs of the Council between its meetings.

4. The President shall have general supervision of the affairs of the Society under the direction of the Council. He shall preside at the meetings of the Council at which he may be present and shall be ex-officio member of all committees. He shall deliver an address at the annual Convention of the Society.

5. Vice-Presidents or Directors, in order of seniority, shall preside at meetings of the Council in the absence of the President.

6. The Treasurer shall be the custodian of all moneys. He shall make an annual report, which shall be audited, and such other reports as may be prescribed. The Treasurer and the Secretary, with the advice and consent of the Committee on Finance, shall invest such funds as may be ordered by the Council. They shall pay all bills when audited by the Committee on Finance and approved by the Council.

7. The Secretary shall be, under the direction of the President and the Council, the executive officer of the Society. He shall prepare the business for the Council and record the proceedings thereof. He shall collect all moneys due to the Society, and deposit the same subject to the order of the Treasurer. He shall personally certify the accuracy of bills or vouchers upon which money is to be paid, and shall draw and countersign all checks, which shall be signed by the Treasurer when such drafts are known by him to be proper, are duly authorized by the Committee on Finance and in accordance with the necessary vouchers transmitted by the Secretary with the draft. He shall have charge of the books and accounts of the Society, and shall furnish monthly to the Council a statement of receipts and expenditures and monthly balances. He shall present annually a report to the Council for publication in the *Transactions,* and from time to time shall furnish such statements as may be required. He shall conduct the correspondence of the Society and keep full records and perform such other duties as may be assigned to him. The Council may appoint assistants to the Secretary; one of these may hold the title of Assistant Secretary, and shall be under the immediate direction of the Secretary and aid him in all matters.

8. The President shall, at the first meeting of the Council after his election, appoint, subject to the approval of the Council, the following standing committees: A Committee on Finance, of three members; a Committee on Papers, of five members; a Committee on Editing and Publication, of three members. He may also appoint temporary committees from time to time. Two of the three members of the Finance Committee shall be members of the Council, and the other standing committees shall include at least one member of the Council.

9. All committees shall be directly responsible to the Council, and shall act under its direction. The Council may at any time, at its own discretion, remove any or all members of a committee, and thereupon the President shall forthwith appoint others, as hereinbefore provided; in the failure of the President duly to appoint such committee, the Council may make the appointment. The terms of the members of all standing and temporary committees

shall terminate on the second Friday of January of each year, when the incoming President shall reconstitute the membership of all standing committees and of such temporary committees as may have further duties to perform.

10. The Committee on Finance shall have direct supervision of the financial affairs of the Society, and shall present to the Council an annual report on its financial condition. It shall approve all bills before payment, and shall make recommendations to the Council as to the investment of moneys and upon all specific appropriations. No payment other than routine office expenses shall be made by the Secretary or Treasurer, except upon the authorization of the Committee on Finance.

11. The Committee on Papers shall have general supervision of all papers to be presented before the Society, and shall have the duty of preparing the programmes of general meetings of the Society and procuring papers for presentation before such meetings. No paper, discussion, communication or report shall be printed in the *Transactions* of the Society or elsewhere until approved by the Committee.

12. The Committee on Editing and Publication shall edit all discussions of papers presented before the Society or any section thereof, and shall decide all questions of detail regarding the publication of papers, discussions and communications. The *Transactions* and other publications of the Society shall be in direct charge of this Committee.

13. Five members shall constitute a quorum of the Council. The "Vote of the Council" shall be a vote of the majority of the members present and forming a quorum, except where a letter-ballot is prescribed, when the "Vote of the Council" shall be a vote of a majority of the entire membership of the Council.

ARTICLE VIII. MEETINGS.

1. The annual meeting of the Society shall be held at general headquarters the second Friday of January, when a report of the proceedings of the Society for the past fiscal year shall be presented by the Council, which report shall be verified by a majority of the Council, including the President, Treasurer and Secretary.

2. An annual convention of the Society shall be held on a date and at a place fixed by the Council, for the presentation and discussion of professional papers and subjects. The President shall deliver a presidential address at this meeting.

3. Other meetings of the Society as a body may be held at such time and place as the Council shall direct, at which no business affecting the organization or policy of the Society shall be transacted. Notice of all such meetings shall be sent by mail or otherwise to all members at least ten days in advance of a meeting.

ARTICLE IX. SECTIONS.

1. Sections of the Society may be authorized in any State or locality where the membership exceeds 50.

2. Each section shall nominate and elect a Chairman, two Managers and a Secretary.

3. The officers of sections shall be elected annually at a meeting held in January, the term of office to be one year.

4. The business of a section shall be conducted by a Board of Managers, which shall consist of the Vice-President of the Society representing the locality of the section, and the Chairman, Managers and Secretary of the section.

5. A section may formulate By-Laws for its conduct, which shall conform with the Constitution and By-Laws of the Society, and with its policy as fixed by the Council. Upon approval by the Council, proposed By-Laws may be adopted by a two-thirds vote at a regular or special meeting of the section, notification of such meeting, together with a copy of the proposed By-Laws, shall be sent to all members of the section at least ten days prior to the date fixed for its holding.

6. The expenses of sections incurred for postal card notices of meetings and stenographic reports of discussions shall be paid from the general fund of the Society. In cases where there is no desirable auditorium available free of charge, the Council shall authorize the rental of a hall, the expense to be payable from the general fund of the Society. Other expenses than these to be payable from the general fund of the Society must first be authorized by the Council of the Society.

7. A Section Board of Managers may authorize, and shall provide for the payment of by local assessment, any expenses of a section beyond those authorized to be paid from the general fund of the Society.

8. Any proposed action of a section not relating to the holding of meetings and the discussion of papers shall be submitted to the Council of the Society for approval prior to being put into execution.

9. Papers shall be approved by the Section Board of Managers prior to presentation before a section. Manuscript of papers approved should be forwarded to the Committee on Papers sufficiently in advance of date of presentation to enable advance copies, if a paper be approved by that Committee for general presentation, to be printed and sent to all sections for distribution prior to presentation before the sections.

10. The Section Board of Managers shall annually, at the first meeting of the Society year, appoint a Board of Examiners to pass upon applications for membership.

11. The Secretary of each section shall distribute the stenographic reports of discussions to members of the section for revision and forward the corrected reports to the General Secretary of the Society.

12. Should the membership of a section fall below 50, or the average attendance at meetings not warrant the expense of maintaining the organization, the Council may cancel its authorization.

13. Sections shall abide by the Constitution and By-Laws of the Society and conform to the regulations of the Council. The conduct of sections shall always be in conformity with the general policy of the Society as fixed by the Council.

ARTICLE X. GENERAL.

1. The fiscal year of the Society shall be the calendar year.

2. A quorum of the Society shall consist in number of one-tenth of the total number of members, as printed in the Roll of Members last issued. Every member entitled to vote at any meeting may do so by proxy; provided, that there shall be no voting by proxy in the election of officers.

3. After the first election of the Society under this Constitution, the term of one-half of the Vice-Presidents elected shall be one year and of one-half two years, the selection to be by lot; should the number of Vice-Presidents be an uneven number, the major number in the nearest equal division shall have a term of office of two years. Similarly, the term of three Directors shall be one year and of three Directors two years, the selection to be by lot.

4. Officers incumbent at the date of adoption of the Constitution shall retain office, the managers under the Constitution superseded to be known as Directors. Immediately upon the adoption of the Constitution, the Council shall call a meeting of the Board of Nomination, and provide for a speedy election under the general requirements of Article VI., of the additional officers under this Constitution, waiving the dates therein prescribed.

5. A Board of Nomination to prepare the nomination ticket for the additional officers provided for in this Constitution shall consist of the Past President, the senior officer of each section of the Society and four members of the Council to be named by that body.

6. At their next meeting after the adoption of this Constitution, the sections of the Society shall elect the officers provided for in Article IX., Section 2.

ARTICLE XI. AMENDMENTS AND BY-LAWS.

1. Proposals to amend this Constitution shall be made in writing to the Council and signed by at least 25 members, and shall reach the Secretary not later than November 1. The Council shall consider such proposals and direct the Secretary to send out a letter-ballot on their adoption. Votes to be considered shall be received not later than December 26, and shall be referred unopened to the Committee of Tellers, who shall count such votes and make a sealed report, which shall be presented at the annual meeting. An affirmative vote of two-thirds of the entire vote cast by qualified members of the Society shall be necessary to secure the adoption of an amendment. An amendment shall take effect twenty days after its adoption.

2. By-Laws in interpretation of the spirit and letter of this Constitution and for its execution may be adopted by a majority vote of the entire Council. Votes on By-Laws shall be by letter-ballot. Each By-Law proposed or adopted shall state the Article and Section of Article of the Constitution to which it relates.

Papers Read Before Technical Societies

LIGHTING OF RAILWAY PREMISES INDOOR AND OUTDOOR

By Henry Fowler, of Derby.

Read before the Institution of Mechanical Engineers. (Slightly abridged.)

Although from the title the above subject may only appear to appeal to a small class of members, yet it will, on consideration, be seen that on a railway, with its various buildings, stations, yards, shops, etc., nearly all conditions occur which are likely to be met with by engineers. The author has, during the last ten wears, been employed on work of this description on two English railways, and believes that, with the exception of a few isolated cases, more attention is paid to this matter in this country than on the Continent, whilst the company he has now the honor to be employed by may, he believes, claim to be amongst the best lighted in the British Isles. The examples given in this paper are naturally taken from the line on which the author is employed and has charge of lighting by gas and oil. As it is in the majority of cases impossible to give actual costs which would be of general use, he will endeavor, where feasible, to give figures of quantity only, leaving anyone interested to put in prices to suit their particular cases.

The lighting on a railway is chiefly provided by means of oil, gas, or electricity, the choice of the agent used depending upon its availability and other circumstances. It may be generally assumed, however, that oil in ordinary lamps is only used at unimportant points, and where no other means are available. Some few years ago, however, a system of vaporizing ordinary petroleum under pressure and burning the resulting gas in a Bunsen burner was devised, and by this means a very powerful light is available at points where previously the lighting was a matter of difficulty, owing to their not being near a gas supply and not large enough to warrant the erection of an electric generating station. More recently there have been a number of more or less satisfactory petrol lamps devised, in which the liquid is vaporized by the burner itself.

Gas is probably the most general illuminant, and has been able to maintain its position in the majority of places, owing to the introduction of incandescent mantles by Auer von Welsbach. Recently several systems have been introduced of compressing the gas, to allow of a better mixture of gas and air being obtained, and a larger unit of light being where necessary available.

Electricity was first chiefly used in arc lamps, and has proved very satisfactory where a large area has had to be illuminated. But recently, on railways as elsewhere, the need of a cheaper and smaller light has been felt, and this will doubtless be shortly supplied by some of the various types of lamps (Nernst, Mercury-Vapor, etc.) at present being perfected.

Illumination.—Although it may seem a truism, it is nevertheless a point frequently overlooked that illumination of an object is the ultimate goal of all classes of lights. This not only depends upon the power of the light itself, but on the reflector, the color and character of the surrounding substances, and the position of the object to be illuminated in relation to the light itself. Under most ordinary circumstances, the objects to be illuminated lie either on a horizontal or a vertical plane. On a railway proper, the station platforms are of the former type, and the station walls, and wagon sides and ends of the latter.

The author has, for several years worked with a photometer which measures the total illumination on a horizontal plane with actual examples of lighting, and it is with the results of this work that he proposes to deal. The instrument is a development of the one devised by Messrs. Preece and Trotter and improved by Mr. A. P. Trotter. The apparatus, Fig. 1, consists of a cylindrical metal box, with removable ends, which is divided by metal screens BB into three portions. In one the standard light C is placed, and this

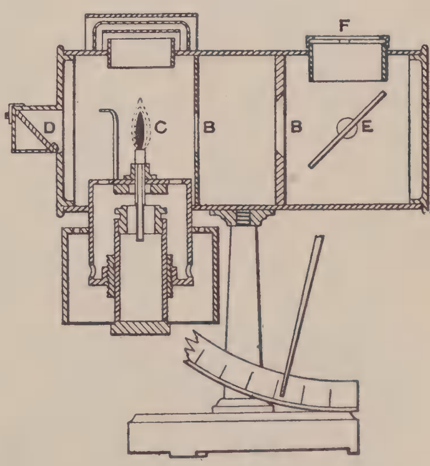


FIG. 1.

consists of a small amylacetate lamp, the wick and burner tube of which can be raised in a tube so that the height of the flame may be kept constant; the proper position is indicated by a pointer. A small mirror D outside the cap of the box allows of observations of the height being taken without removing the cap. In the other portion of the box there is a small pivoted screen E, upon which the light from C is allowed to fall through a hole in the screen B. On E is fastened a piece of white Bristol board. Directly above E is a circular disc F (also of Bristol board) fitted into the top of the box, and in the centre of this disc is a long narrow slot lying at right angles to the axis of the cylindrical body. In working the instrument the disc F is placed in the plane at the point at which the illumination is required, and the screen E viewed through the slot. The amount of light falling on E will be dependent upon the angle at which it lies relative to the light, and it is therefore moved until the illumination on the screen, as viewed through the slot, balances that on the disc. The amount of illumination in foot-candles is then read off, by the position of a pointer attached to a pivot of the screen, on a scale, the latter having previously been calculated by means of lights of known intensity. When measuring lights of a color different from the reddish tinge of the amylacetate flame, it is necessary to vibrate the screen slightly between the points where the light through the slot appears lighter and darker than the disc. A mean of the maximum and minimum readings will give the correct reading. In all cases some experience with the photometer is necessary before correct results may be expected, but with practise the instrument seems to give reliable results.

The author is perfectly well aware that objection may be raised on the ground that this instrument is not an absolutely correct one, but it is the only one of its kind on the market, and he has found that in the same hands it gives comparable results.

Horizontal and Vertical Illumination.—The question of whether in estimating the lighting required the horizontal or the vertical illumination is to be considered is dependent upon circumstances, and upon the decision arrived at depends the height at which the lamps should be fixed. A man on a street or railway platform instinctively holds any article he is carrying, and which he wishes to read, in the position in which it is best illuminated, which is at right-angles to a line drawn from the point of illumination to the article. With railway lighting both planes have to be considered, for even in a station the lighting of the walls of the building, as well as the surface of the platform, has to be taken into account. At junctions or points in sidings, the vertical illumination is by far the most important, as it allows the positions of wagons to be seen and the labels on the sides read. As a general rule, however, the author has found that where the horizontal illumination is properly provided for, the vertical will be found to be satisfactory, and in all the curves which follow, the mer is the illumination which has been measured.

PASSENGER-STATION LIGHTING.

Arrangements of Lights.—The space to be lighted in a station consists mainly of the platforms, and this necessitates the lights being placed in long lines down these platforms. The best position for these is nearly in the centre of the space to be lighted. Where there is a wall or building on one side, and the platform edge on the other, they should be slightly nearer the former, as the lamps are usually employed, in addition to their use for lighting purposes, as a means of denoting the name of the station. On open platforms, columns, etc., form obstructions, and are therefore placed so as to leave as great a space as necessary between them and the platform edge. It is absolutely essential that the edge of the platform itself should be well defined.

Restriction of Position.—In many cases the positions of the lamps are to some extent determined by the positions of buildings, passages, etc., which have to be lighted, and by the roof which may allow of lights only being fixed at multiples of certain distances apart.

Height.—This is a most important point, not only in station lighting, but in all other, as upon it depends the general character of the horizontal illumination. The ideal arrangement is to have a light of great intensity fixed at great height, when the illumination will be as even as possible. This of course is impracticable and would lead to much loss of light, as only a small portion of the spherical intensity would be utilized. In actual practise the distance the lights are apart has to be taken into account, and although Mr. Trotter has spoken in favor of the ratio of height to distance being as 1 to 3, yet in ordinary railway work the ratio for station lighting is usually not less than 1 to 5 or 1 to 6, and still the effect is good. The spherical intensity of a light has of course to be taken into account, and the curves of angular candle-power.

An electric arc should, if patchiness is to be avoided, be placed fairly high. Above all things, in lighting any space effectively, the fault of patchiness should be avoided. Nothing is more displeasing than to have violent contrasts of illumination close together, and often a portion of a space looks badly lighted, simply owing to its being

compared with a much more brilliant patch near it. All variations of illumination should be as gradual as possible, and this is one of the chief reasons for surrounding arc lamps with opaque globes, which, although they retard a portion of the light, allow a better general effect by distributing the light more evenly. On a railway station the lowness of the roof often prevents the lights being placed at the desired height, and in these cases the only satisfactory method is to use a number of small units close together so that contrasts in illumination may not be too marked.

Effect of Train Lighting.—In many small stations the effect of the light given by the train must not be forgotten. The passengers are so few that they can often be accommodated in the waiting-rooms, and only use the platform when the train is in, and when the carriage lamps give a good light on to the platform itself. In these cases all that is necessary is to provide sufficient light to prevent accidents.

Types of Stations.—Undoubtedly the best type of station to light satisfactorily is one with a large span roof, the sides of the buildings being of light-colored glazed bricks. Various considerations often prevent these being built, and then the precautions already mentioned should be taken in order to ensure satisfactory lighting.

OIL LIGHTING.

Its Inefficiency.—It is scarcely necessary to say that lighting by oil is only employed at small stations where no other form of illumination is available. It requires more attention than any other type, but at a small station this is not usually a matter of importance. In some exposed situations it is a matter of impossibility to light the lamps in position during very rough weather, and in such instances special inner lamp-cases have to be provided, by which means the lamps can be lighted indoors and the whole carried to and placed in the ordinary lamp-case. The advantages of oil lighting are its simplicity, and the low cost per burner-hour for a light which, in many cases, is sufficient for the use to which it is put.

Many attempts have been made to use ordinary petroleum directly with incandescent mantles, but only with partial success, as special care is needed to keep the flame purely a Bunsen one. There is, however, a highly successful lamp which vaporizes the petroleum and uses the gas formed with an incandescent mantle. This is the Kitson light, which has been used in this country now for about five years, and a drawing of which is given in Fig. 2. The small copper pipe A, of about 0.125 inch internal diameter, is supplied with ordinary petroleum from a cistern where the air on the top of the liquid has a pressure of from

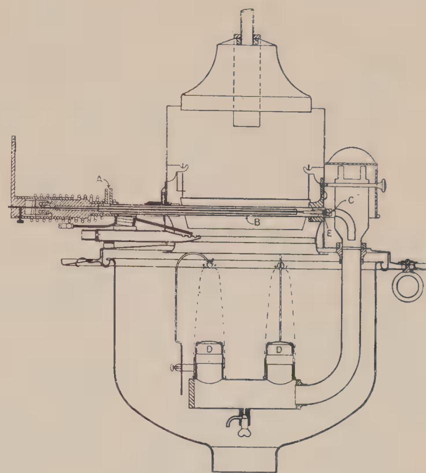


FIG. 2.

12 to 60 pounds per square inch, which pressure is supplied by a small air-pump. The cistern, in the case of station lighting, may supply a number of lamps, but with isolated pillar lamps, such as in sidings, each column has a cistern in the bottom, and each lamp is independent. The oil is led from the copper pipe A into the vaporizer B, and through the small hole or sprayer C to the burners DD. It is absolutely necessary that the oil and casks should be as clean as possible, or the hole C, which is only about 0.016 inch in diameter, may become blocked, the supply of oil checked, and the light extinguished. In order to clear any obstruction which may get through, a picker E is provided, consisting of a needle-point, which can, by means of a chain below the lamp, be made to enter the hole C and clear out any obstruction which may be blocking it. To start the lamp, the vaporizer is heated by means of a gasoline or petrol blow-pipe operated from below, and lighted by an electric lighter. When sufficiently hot the oil is allowed to enter the vaporizer, and the vapor rising through the burner becomes ignited. The gas issues at a high pressure and the flame is very hot, with the result that the light given is intense. As a rule two burners are fixed in each lamp, so that if one fails the other continues to give light. The average candle-power of one of these lamps tested on a photometer bar was 781 candles for a consumption of oil of 0.1135 gallon per hour. This works out at 8.3 grains per candle-hour, which of course is far in advance of any other type of lighting by means of oil. The cost of maintenance of these lights varies very much with their situation, and the following figures, which relate to lamps used in two exposed sidings for four years, are the

only ones the author has personal experience of, although at least one large station is lighted by such lamps in this country. Wages have been left out, as the installations mentioned consist of fourteen isolated lamps only, and this item would be much smaller per lamp if a larger number of lamps required attention.

Total number of lighting hours, 54,989.

Number of lamps, 14.

Petroleum used, 3.990 gallons=0.0726 gallon per lamp per hour burning.

Number of mantles used, 468=0.0085 mantle per lamp per hour burning.

Gasoline used, 42 gallons=3 gallons per lamp per annum.

Repairs, renewals, small stores, etc., exclusive of wages, £14 8*s.* 1*d.*=£1 0*s.* 6.93*d.* per lamp per annum.

From the candle-power of these lamps it will be seen that they are only suitable for station lighting when they can be placed high up above the platform, unless a very strong light is required.

Other Lighting for Small Stations.—Acetylene.—Of the various other systems of lighting small stations, one of the most satisfactory is the use of acetylene. This is readily generated from calcium carbide, whilst most types of generators require very little attention. This has led to its adoption by many railway companies, but its expense has prevented its being generally adopted. To give a light comparable with that of a Veritas oil lamp, at least 1 foot per hour must be burnt, and with carbide at £15 per ton this means a cost of 0.36*d.* per cubic foot; and assuming that this gave 50 candle-power, the same light could be given with a Veritas oil-lamp for the same cost, even if oil were 8*d.* per gallon, neglecting cost of generation. (It has been assumed that 1 candle-hour takes 50 grains.) Acetylene can therefore only be used under special conditions.

Carburetted Air.—Since the cheapening of the cost of petrol, consequent upon the greater demand for it for motor-car purposes, very many attempts have been made to use it for carburetting air for use with incandescent burners, the gas thus made to be used through ordinary gas pipes to supply these burners. It need scarcely be said that special precautions require to be taken before the storage of even a small quantity of such an inflammable liquid as petrol can be allowed on a station, but arrangements can be made to render the risk of danger very slight indeed.

The air is usually carburetted by passing it over or through the petrol, which is very volatile and gives a vapor capable of being carried by the air in certain proportions. Very much ingenuity has been shown in the construction of air gas plants, and several seem to be theoretically perfect, but the author has not come across one which has been tried practically with absolutely satisfactory results. In some cases variation of temperature leads to some of the petrol being dropped in the pipe, whilst in others the mixture of air and petrol vapor is not constant as it should be, which leads to trouble at the burner. In nearly all cases the apparatus is not simple enough to leave in charge of the staff of the small wayside stations, where this class of lighting would prove particularly useful. In the case of one apparatus the author has experimented with, in which a portion of the gas made was used by a small hot-air engine for working the plant, a gallon of petrol gave 1,240 cubic feet of gas which had a calorific value of 90.35 British Thermal Units. When this was burnt in an incandescent burner, 9.45 cubic feet per hour gave a light of 44.98 candles. Fig. 13 is an illumination curve of a station lighted by this means, the lamps being 65 feet 6 inches apart, the light 7 feet 9 inches above the photometer, and the curve taken along a line 9 feet 6 inches from the centre line of the lamps.

Petrol Lamps.—Many types of independent petrol lamps are on the market, and these in the majority of cases have a vaporizer under the burner, which is provided with an incandescent mantle, the petrol being fed from a supply above the lamp. A portion of the heat from the burner is thrown down on to the vaporizer, but as petrol is not so volatile not much is required for this purpose. As a rule these lamps require their vaporizers to be heated slightly before turning the petrol on. Their disadvantages are the attention they require to light and keep in order, and the danger in having so many small supplies of petrol on the premises. In a lamp recently put on the market, the petrol is allowed to soak into an absorbent block, and gas is made by syphoning air through this to the burner. Other lamps on somewhat similar principles to the first-mentioned of this type use methylated spirit, but this adds materially to the cost.

The author believes that there is a future before petrol-fed lamps, but the time for their general adoption has not yet come.

Oil Gas.—Lighting by this means is not, the author thinks, carried out on any railway station. It would require the provision of a set of retorts, and considerable storage if the retorts were not to be kept on continually. The cost would probably be slightly more than acetylene when all charges were taken into account.

Gas Lighting: Flat-Flame.—Until a little more than ten years ago, except in a very few isolated cases, gas was the general illuminant for stations of any importance, and was almost universally used in an

open, or flat-flame burner. It need scarcely be said that the lighting was not only poor, but, by present experience, costly for the results obtained. Although this type of burner is rapidly becoming out-of-date on all stations where many trains are run at night, yet it still supplies the greater part of the lighting on several of our British lines. On every company's system there are a number of stations on branches, etc., where the trains are not run late in the evening, and where artificial light is only required for a short period each evening, during a few of the winter months. In cases such as these the flat-flame burner will probably continue to be used for some time, as the lighting required is not sufficient to make it worth while to employ incandescent burners, which, although much more efficient, require a certain amount for upkeep. It may be said that the difficulty might be overcome by only putting the incandescent burners on during these winter months, but it must be remembered that the lights must be available in cases of emergency at a moment's notice, and flat-flame burners allow of this with a minimum of trouble and expense.

Incandescent Gas Lamps.—The greatest stride in gas lighting on railways and elsewhere was undoubtedly made when Auer von Welsbach devised his system of utilizing a Bunsen gas flame for heating to incandescence a mantle cantaining the rare earths thorium and cerium. The author is not concerned in this paper with the reason for this incandescence, but only with the practical results it has given in his work. The construction, too, of the ordinary incandescent burner is too well known to need description. An ordinary C burner, using a gas giving 700 B.T.U. per cubic foot and consuming 3.0 cubic feet per hour, can be depended upon for giving a light on a photometer bar averaging 44.25 candles for 1,000 hours. A curve, Fig. 3, gives the average candle-power of a number of mantles for 2,000 hours, as that is the length of time the author tests samples from various consignments. When the fixing solution of a mantle is burnt off, there only remain the ashes of the cotton stocking from which it was made and the rare earths, in solutions of which it has been dipped. It would at first sight seem that this was all too frail to stand the vibration which must exist on railway premises, but experience shows that this is not the case On the Midland Railway there were in use on June 28, 1906, 48,392 of these burners, and although they are employed in all situations, the mantle consumption cannot be said to be high, as it only averaged 5.2 mantles per burner per annum. Under ordinary circumstances with pillar lamps, where a good foundation for the pillar

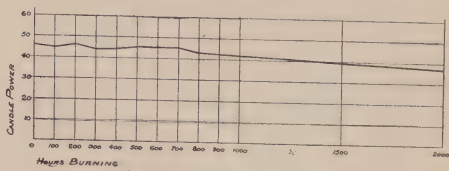


FIG. 3.

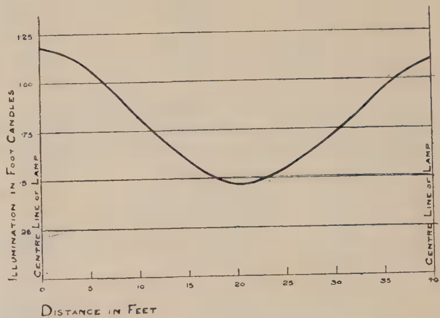
has been secured, and in nearly all cases with suspended lamps, it has not been found necessary to provide any type of antivibrating apparatus to preseve the mantles. When, however, a good foundation cannot be secured, and the vibration is excessive, the use of a simple apparatus, consisting of a frame suspended by a spring on which the burner is fixed, and to which gas is supplied by a rubber connection at the bottom, has been found advantageous.

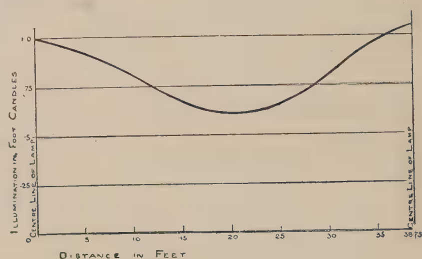
It will doubtless be noted that the author has so far only mentioned the ordinary C incandescent burner: he is perfectly aware that various Kern type of burners with their longer and better designed mixing chambers for the gas and air give a higher efficiency, but he has found that they require greater attention than those of the C type. On the photometer bar this type of burner (Kern) will give over 20 candles per cubic foot of gas burnt per hour, but for the reason stated he has not recommended their general use on the line. As will be readily understood, the number of burners inserted in a lamp and the distance of the lamps apart is a matter to be considered in each particular case. Having a unit of light of about 50 candles (of which any multiple can be easily provided) allows of a very even lighting being obtained where necessary. As a rule not more than three burners are grouped together for station lighting, although groups of five are used in special cases. With small stations single burners, placed as with flat-flame lamps, about 60 feet apart, give a good effect. Generally the lamps are spaced closer together under a station roof than in the open, for this latter is the portion of the station most in use. As a rule the distance between the lamps rarely exceeds 70 feet, and not often are they closer together than 40 feet, whilst the height of the mantle above the platform varies from 9 feet 6 inches to about 14 feet

High-Pressure Incandescent Gas.—Many attempts have been made to get a greater efficiency out of a cubic foot of gas than is given by an ordinary incandescent burner at pressures up to two inches of water. Some four or five years ago it was found that by using a much higher pressure than usual and allowing the air and gas to mix together in a longer chamber, better results were obtained. The pressure used

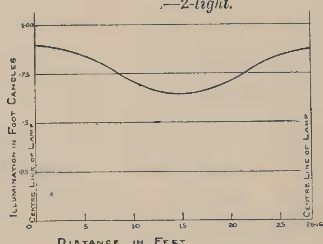
was that of from 8 to 10 inches of water. The mantles are without chimney, and at a pressure of 10 inches of water give 240.68 candles with a consumption of 10.18 cubic feet of gas per hour. It would seem that the best efficiency is obtained with a burner of this size, and it is not always that so large a unit of light is required, but, when it is, the use of such burners is economical. Arrangements have to be made to raise the gas to the required pressure from one to three inches of water, which is the pressure of the usual supply. This is done by pumps which may be driven by water, a gas engine, or electric motor. In the earlier types of plant, water-power was extensively used, but as the amount required varied from 188 to 327 gallons per 1,000 cubic feet of gas compressed, it will readily be understood that this method was found to be in some cases expensive. More recently small gas engines have been used for driving the compressing pumps, and in a plant, the carrying out of which the author has had charge of, the gas consumed by the gas engine has been only 20.8 cubic feet per 1,000 cubic feet of gas compressed. This plant, which will consist of over 300 burners when complete, is giving very good results, from a lighting and economical standpoint, with two-burner lamps placed 56 feet apart and with mantles 13 feet above the platform. A curve of the illumination is given in Fig. 8, the line being 11 feet 6 inches from the line of the lamps. The lighting effect is very good, and free from patchiness. As previously stated, it is not every station where the illumination required necessitates the use of as large units of light. The mantle consumption of burners of this type is higher than with ordinary ones, and may under railway conditions be taken as 8-10 mantles per annum.

More recently several systems of lighting have been devised in which the pressure at which the gas is burnt is very much higher, rising in some cases to 54 inches of water. The result is that a still greater efficiency

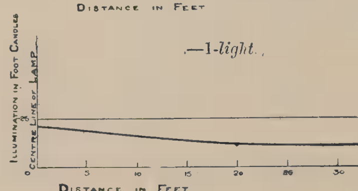




—2-light.



—1-light.



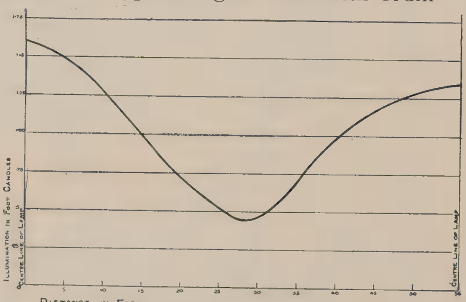


FIG. 8.

FIGS. 4 TO 7.

5-light lamps,	41 ft. apart,	readings	1.18 max.	to	0.45 min.
3-light "	38 ft. "	"	1.1 "	"	0.6 "
2-light "	28 ft. "	"	0.9 "	"	0.65 "
1-light "	58 ft. "	"	0.23 "	"	0.10 "

5-light curve.	Height of lamps 10′ 10″.	Curve taken 6′ 0″ from line of lamps.
3-light "	" " 10′ 4½″.	" 6′ 3″ " " "
2-light "	" " 9′ 8″.	" 5′ 9″ " "
1-light "	" " 9′ 9″.	" 6′ 0″ " "

per cubic foot is obtained, but the unit of light is raised higher than is usually required for railway purposes. One railway company employs one of these systems for dock lighting, whilst one of the best pieces of street lighting the author has seen, that of Alexander Platz, Berlin, is with this type of burner.

Self-Intensified Burners.—The provision of high-pressure gas necessitates the laying of special mains, or at all events of having gas of a higher pressure in the mains than is usually the case. This has led to the invention of several types of lamps which are arranged to give the same effect independently, either by induced draught or by the provision of some mechanism in the head of the lamp for raising the pressure of the air supply to the burner to about 30 inches of water. Some of these types seem to work admirably, but the author has not had sufficient success with them to cause him to recommend their adoption extensively, but this may be due to local conditions. At all events, the results aimed at are those given in the figures mentioned with high-pressure lighting.

Interior Lighting.—Interior lighting on a station in the majority of places is confined to small rooms, with the result that the light is usually required at some particular point, and consequently it is placed as near this point as possible. About the largest interior spaces requiring attention are parcel offices, and in these it is found that an illumination varying from 0.9 of a foot-candle on the floor gives good results. This can be obtained by three-light suspended C gas burners placed under an enameled reflector.

Within the last year or two the inverted type of burner has been much improved, and the smaller types supply a want in gas lighting, as they give an economical light of about 12 candles.

This type of burner lends itself to much more artistic treatment with its fittings than any other type, but this is not a point which gets much consideration in lighting a railway, except perhaps in refreshment rooms.

ELECTRIC LIGHTING.

Electric lighting is at present, owing to the development of Nernst, mercury-vapor lamps, etc., somewhat in a state of transition, and the author proposes to confine his attention at present to the consideration of arc and incandescent lights only. He is anxious to admit that the latter type of lighting will probably before long occupy the place of the flat flame in gas lighting, but he believes that the new type of lamps have not as yet been generally adopted for railway lighting, although he knows that they are employed in several instances.

Arc Lighting.—In order that this type of lighting may be used to the greatest advantage on a station, it is necessary, owing to the high unit of light given by the most satisfactory type of lamp, that it should be placed fairly high up, and in fact that the ratio of height of lamp to distance apart should not be greater than 1 to 4 or 5. This is due not only to the fact that the unit of light is high, but that the carbons shaping themselves as they do cause the maximum of light to be thrown down at an angle of about 50° to the vertical. This difficulty may, as previously stated, be reduced by placing a slightly opaque globe round the arc, but this leads to a certain loss of the total light given off. One disadvantage of a very high light is the difficulty of attending to it in re-carboning unless arrangements are made for dropping the lamp. The type of lamp usually employed is a 10-ampere, 500-watt one, and unless otherwise stated this is the class of lamp used in all the curves which follow. In some cases enclosed types of arcs, using, however, about the same amount of current, are employed. This type of lighting is particularly good when the space to be lighted is large and when the height required for satisfactory illumination can be obtained. On the Midland Railway several large stations are lighted in this way, and one station in particular deserves attention, as the roof is high and the walls light colored. Fig. 9 is a curve of the illumination between two lamps at this station, taken along a line 7 feet 3 inches from the line of the lamps. The rings of increased lighting under a globe, owing to slight variation in the glass, have a bad effect in arc lighting, and globes should be as perfect as possible at the bottom to prevent this appearance of

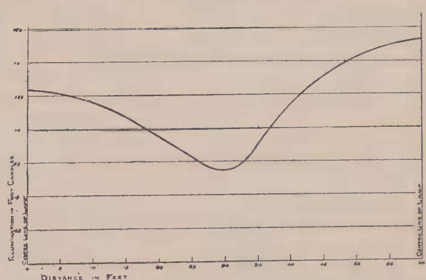


FIG. 9.

patchiness. The advantage of being able to switch the electric current on at once is too well known to need mention here.

Incandescent Electric Lighting.—With some railway companies, these lights are employed for lighting platforms on some of the smaller stations, but as a reliable lamp takes at least 3.5 watts per candle, current must be cheap in order to make it at all

economical. For interior-station lighting it is much more satisfactory, as in many cases an 8 candle-power lamp over a desk is all that is required, and the small "Bijou" incandescent gas-lamp is the only thing which can compete with this.

The author is fully aware that he has only dealt with electric lighting in an incomplete manner, and he can only trust that if there is any special point to which attention should be called, the question will be raised in the discussion.

GOODS YARDS AND SIDINGS.

In the previous section detailed description was given where required of each particular lamp as mentioned, and it is not therefore necessary to revert to them, but simply to mention them when referring to the effects obtained by their use.

In lighting these places, as distinct from goods sheds, two conditions may obtain; it may be that it is necessary to provide for lighting a space, as for instance, the entrance of a yard, or a particular point, such as a capstan. Upon these considerations the type of light used will depend. In the first case high-powered lights are required, and they should be placed high up so as to distribute the light; in the second case a smaller light at the point required is all that is necessary. For the lighting of the yards themselves three-light incandescent gas lamps about 80 to 100 feet apart, or arc lamps about 100 to 120 feet apart, give a good effect, and quite sufficient illumination under ordinary conditions. It frequently happens, however, that the necessity for providing light at some particular point, such as a crane, capstan, crossing, etc., causes the lamps to be placed much closer together. In small yards where neither electricity nor gas is avilable, Veritas oil lamps in suitable cases may be used. It will be understood that the conditions vary so much that illumination curves of lighting of this description are not of much value, but from a number of readings which the author has taken, he thinks that if the light provided does not sink below 0.05 foot-candles at the ground-level it will meet any case. In the lighting of sidings, the chief position to be considered is that of the points. Here it is necessary not only to light the points themselves, and the position of the "dummy" for changing them, where provided, but also to show when a wagon is standing clear where the roads diverge, so that shunting may take place safely by it. The lighting here required is therefore a combination of horizontal and vertical illumination, and if a single pair of points has to be dealt with, a light of not too high power (say 100 candles), placed at not too great a height, is all that is required. Where several sidings run one after another into a shunting road and a line of lights is provided, three-light incandescent gas lamps, 100 feet part, or arc lamps on higher posts and spaced a greater distance, will be found satisfactory. In some cases special lighting has to be provided, and as a case in point the author would quote gravitation sidings such as now exist on most railways. Here the number of the road the wagon is to go on is chalked on the end of the wagon before it is "cut" from the train and started down the incline. It is necessary that this number should be easily read, and in order that this may be done, the author has found that three-light incandescent lamps, with reflectors behind the mantles, on fairly low posts answer this purpose admirably. At points where trains are broken up on these sidings, a particularly good light is required, and a minimum illumination of 0.15 foot-candle will be found none too much. In sidings where neither gas nor electricity is available the "Kitson" pressure oil lamp will be found very useful.

Goods Sheds.—Here, even more than on stations, the points available for fixing lights are very confined. It often happens that the jibs of the cranes sweep so close to the principals of the roof that the space left between is too small to allow of the fixing of a light, whilst such a position would be a dangerous one for men attending to the lamps when this became necessary. The result is that lights are usually fixed along the stage of a shed, not down the center but "staggered" on alternate sides so as to miss the swing of the cranes. An ordinary shed consists of stages with cranes, with a cart-way on one side and a siding on the other. The cartway is often so wide as to require some light down it, and this is provided by a line of lamps placed at sufficient height to prevent damage from high loads. On the stages a good light is essential, owing to the necessity of reading quickly and easily labels on goods, written sometimes in all styles of writing with every color of ink. With gas lighting, groups of two or three incandescent burners in lamps placed from 30 to 40 feet apart, and from 11 to 13 feet above the platform, are found to give a satisfactory light, the illumination—neglecting the portion directly under the lamp—varying from 0.9 to 0.25 foot-candle. Where arc lighting is used in these sheds, the lights are usually placed 45 to 60 feet apart, and at heights from 13 to 15 feet above the stage level. The illumination varies from 2.25 foot-candles down to 0.4.

Locomotive Sheds.—The sheds of the Midland Railway Company are of two types, either square ("round") with a turntable in the centre and pits radiating from it, or rectangular with an entrance at one end and pits running down the length of

the shed. The lighting was formerly carried out by means of star or similar gaslights with four, six or eight burners, each consuming about five cubic feet per hour. In the case of the "round" sheds these lights were placed between every other pit, with the result that one side of each engine was left in darkness. Upon the advent of the incandescent burner these old lights were replaced by two-light incandescent burners, either in lamps or under shades, which were placed between each pit. The result was that not only was a better and more evenly distributed light obtained, but a considerable economy was effected in the cost of lighting.

Lighting of Workshops.—With the exception of the shops in which the locomotives or carriages themselves are erected or repaired, the general conditions and arrangements in railway works are very similar to those found in any engineering works. Although in a country like this, under existing conditions, work must be carried on after darkness sets in, yet lighting of shops is a subject which the records of the Institution show has not been as frequently discussed as it would seem to merit. This is particularly the case when it is remembered what great strides lighting, both by gas and electricity, has made during the last 10 or 15 years. In October, 1893, Sir (then Mr.) Benjamin A. Dobson read an interesting paper on "The Artificial Lighting of Workshops," in which special reference was made to the use of inverted arc lamps placed under large whitewashed reflectors. This class of lighting is particularly effective in many cases, but as it was so fully dealt with at the time, the author does not propose to refer to it here, as any member interested can work out from the particulars then given the cost with the price of current adapted to his special case.

Lighting of Locomotive Erecting Shops.—In lighting a locomotive erecting shop, certain initial difficultes are met with. These are, the need of a good, general, well-diffused light, and the fact that, as cranes run down the whole width and length of the shops, the light must be at least 29 feet above the floor-level. The author was met with these difficulties when asked to improve the illumination of a large erecting shop of three bays, each measuring 450 feet by 50 feet. At first arc lamps, under large whitewashed reflecting boards, were tried above the cranes, but for one reason or another were not wholly satisfactory. These lamps were then superseded by arcs placed between the columns separating the bays, but this did not provide a sufficient light in the centre of the shop. About this time a smaller shop was erected at Kentish Town, and the author lighted this by high-pressure gas burners, placing three of these under a whitewashed reflector. The results are very satisfactory. a steady, well-diffused light being obtained, whilst the burners have required little attention and the consumption of mantles has been low. In this case, as so small a number of burners are used, water is employed for raising the gas pressure from one inch of water to eight inches of water, and as an old-type compressor was fixed, the water-consumption has been somewhat high, being 327 gallons per 1,000 cubic feet of gas compressed.

The peculiar shaped reflector is used, as it is easily fixed between the principals, and it effectually prevents much light being thrown on the glass roof and lost, as nearly all the rays fall on it or on the portion of the roof that is painted white. The burners are 36 feet 6 inches from the floor, on which the illumination varies from 0.48 to 0.95 foot-candles.

The success of this lighting led to the

Flat flame burners dispensed with	539	273
Total candle-power of these	5,390	2,730
Incandescent burners fixed	266	141
Total candle-power of these	11,770	6,239
Gas used per annum when flat-flame burners were employed	6,947,800 cu. ft.	4,000,500 cu. ft.
Gas sued per annum after incandescent burners were employed	4,452,500 cu. ft.	2,354,000 cu. ft.
Percentage increase in candle-power	118%	128%
Percentage decrease in gas-consumption	35.9%	41.16%

	Total.	Per Burner.	Total.	Per Burner.
Maintenance of Incandescent Burners per annum:—				
Mantles	1,692	6.36	1,076	7.63
Chimneys	346	1.30	322	2.28
Forks	152	0.57	130	0.92
Wages	£26 0s. 0d.	1/11.46d.	£13 13s. 0d	1/11.23d

same system being adopted at the large shop previously mentioned. In this case the reflectors employed are like the ones at Kentish Town. They are whitewashed, and the author has found in practise that this substance has all the properties of a reflector, as claimed for it by Mr. A. P. Trotter in the paper read by him before the Institution of Civil Engineers. The illumination, 29 feet 8 inches below the burners, varies from 0.8 to 1.4 foot-candles. It is found that the burners only require attention about every 7-10 days. In large buildings such as these, where it is impossible to have a light of this description in any position except at a great height above the work, it is not possible to dispense entirely with lights on the benches themselves, but these can be reduced to a minimum, and are only required where a long hole has to be seen through. Even these could be dispensed with if the vices could be fixed opposite a whitewashed wall.

Brass Foundry.—The satisfaction given by this lighting and its economy has led to its being adopted in all shops where a good general light is required, such as those in which boilers, tenders, etc., are dealt with. It has even been installed in the brass foundry at Derby, and has been found very satisfactory. The height the burners are fixed above the floor (21 feet in this case) is apparently sufficient to prevent their being interfered with by the dust, etc., which is always found in such shops.

Fitting Shops.—In fitting and machine shops, although a general light is required, yet particular points require special attention unless the general illumination is very good. In the discussion on Sir B. A. Dobson's paper, Mr. J. A. F. Aspinall showed by photographs, etc., the success achieved by fixing arc lamps under large whitewashed screens in the fitting shop at Horwich. The construction of this building has allowed of the systematic arrangement of a large number of arc lamps, and the author, who has worked both on machines and at the bench in this shop, can testify to the excellent effect given.

In the shops he has had to deal with, the construction has not admitted of the employment of large units of light, as, to use them successfully, they must be placed at a considerable height above the surface to be illuminated. With gas available at a very low cost, extensive use has been made of the two-light incandescent gas-fitting under a 28-inch enameled shade already referred to. The use of a smaller unit of light, such as this, allows of a much better illumination when the lights have to be fixed lower down. The illumination on the benches in this instance is over 2.25 foot-candles. In such cases as these no type of antivibrator has been found necessary, as the mantle consumption is not heavy.

In some cases, owing to the provision of cranes, or from other causes, it has been found necessary to provide a special light for a vice. In such positions a single light with a special antivibrator (Fig. 10) has

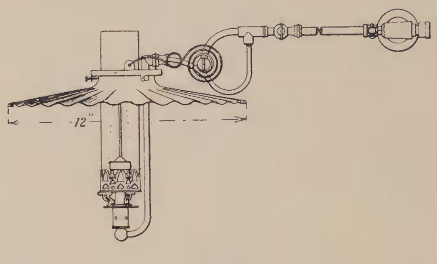


FIG. 10.

proved useful. These have also been employed to light a row of lathes fixed against a wall, and where it was not thought advisable to provide large units of light high up. In these circumstances they are fixed to the wall behind the lathe.

Paint Shop.—In both locomotive and carriage paint shops, not only is a good light required, but it has to be provided in long rows to illuminate thoroughly the vehicles on each side. In dealing with these cases, the two-light incandescent fitting has been found very successful.

Carriage Shop.—With lighting of carriage shops generally, the same conditions occur as are found in locomotive paint shops. These prevent the provision of high units of light, especially as the shops are of necessity not so high as locomotive erecting shops, as cranes are not often used. The same system of lighting has been adopted as with the locomotive paint shop already quoted.

Iron Foundry.—The lighting of iron foundries seems to be one particularly suited to arc lamps, but the author, from his experience with high-pressure gas lights in the brass foundry referred to, believes that this system of gas lighting may successfully be employed in illuminating what is usually the one dark spot about a works.

In conclusion the author would again point out that if he has seemed to deal with the question of gas lighting somewhat to the exclusion of other types, it is because he has of necessity had to speak of the lighting that he has had most to do with. He trusts that any omission may be made good by members taking part in the discussion.

HELION FILAMENT INCANDESCENT LAMP

By Prof. H. C. Parker and Walter G. Clark.

Paper read before the American Physical Society, New York, Dec. 29, 1906.

The Helion incandescent lamp is the result of several years' of research work on the part of the authors in the Phœnix Physical Laboratories of Columbia University. The name Helion is adapted from Helios, and was adopted on account of the resemblance of the spectrum of the light from this filament to the solar spectrum. In some respects the filaments are quite remarkable, as they are not metallic, yet they can be operated at a specific consumption of one watt per candle at a temperature which readings on the Fery absorption pyrometer indicate is very much below the temperature of metallic filaments when operated at this consumption. The Helion filament is composed largely of silicon, which is reduced and deposited, together with the other materials, under very exact conditions. The base which is being used at present is a special carbon filament, on which the necessary deposit is made. The filament is mounted within a globe which is then pumped out, much the same as with the ordinary carbon lamp. When current is applied, the first noticeable characteristic is the white light radiated from the filament at a current density at which the carbon filament would be radiating only red rays. The next characteristic is the whiteness of the light, and the high luminous efficiency of the filament at its normal current density, and next the overload or extra current which it will carry without breaking down. The filament, while not metallic in the proper sense, shows a metallic characteristic in that it is possible to fuse parts of it together very much the same as is done with

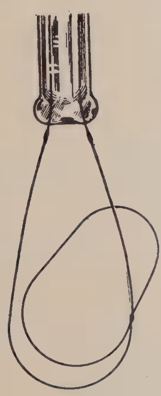


FIG. 1.

a metallic filament. This is demonstrated by the filament shown in Fig. 1, which broke, and then fused together where the parts came in contact.

In early experiments with the filament it was noticed that a point of maximum candle-power could be reached, and that further increase in current apparently did not result in a proportional increase in light. This has been borne out by pyrometer measurements, which are shown on the curve in Fig. 2. It will be noticed that

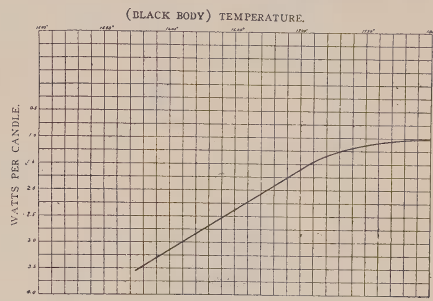


FIG. 2.

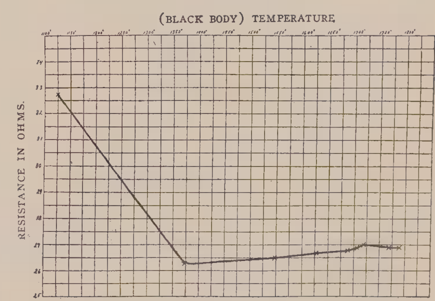


FIG. 3.

the candle-power increases with the temperature in practically a direct ratio up to a temperature (black body temperature) of approximately 1,720°, at which point the curve flattens down, until it is practically flat at 1,800°. In some experiments to determine the overload which the filament would carry, the power applied has been increased by 100 per cent. after the point of apparent maximum brilliancy had been reached, the filament carrying the overload without rupture.

The curve of Fig. 3 shows the temperature-coefficiency of the filament which is at first negative; the resistance of the filament shown in the curve drops from 32¾ ohms at 1,125° temperature, to 26¼ ohms at 1,375°, then increases to 27 ohms at 1,720°, and has a slight negative coefficiency beyond this point. The test shown on this particular curve was made

on a short section of regular filament. It will be noticed that the change from the positive temperature coefficiency to a negative coefficiency, takes place at practically the point at which the ratio of temperature to candle-power makes its greatest change, as shown in Fig. 2. The change occurring at this point would seem to indicate that a molecular alteration had taken place in the filament, but if this is so, it would appear that the same change occurs in a reverse order as the temperature is reduced, for when the filament is allowed to cool and power again applied, the same characteristics are observed.

The amount of overload the filament will withstand is well shown in the lamp illustrated in Fig. 4 where long copper wires were used to place a small loop filament into the middle of the lamp bulb. The current passing through the filament was raised to a point where the copper wire on

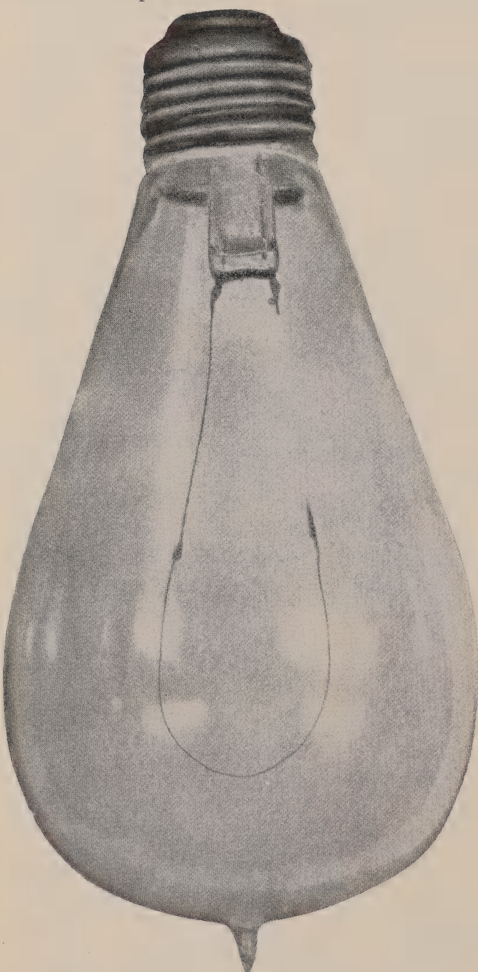


FIG. 4.

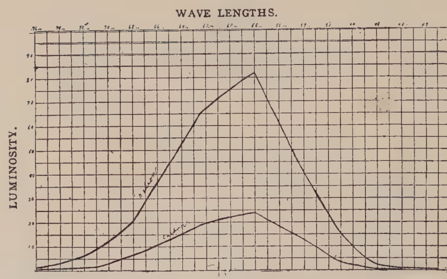


FIG. 5.

one side fused, ran down, and now appears as a metal globule near the neck of the lamp. The cement terminals are intact, and a portion of the copper yet remains at each cement terminal, the copper having fused immediately at the cement covered terminal. The overload does not appear to have in any way injured the filament, which is still intact, and the only discoloration on the glass is a slight deposit of copper on the side near the fused terminal, there being no deposit from the filament on the glass, although the cross section of the copper wire is several times greater than the cross section of the filament.

The curve in Fig. 5 shows the relative intensity of light from a Helion filament and a standard make of carbon filament lamp at various wave lengths in the spectrum, each lamp being operated under normal conditions. The curve shown in Fig. 6 indicates the energy consumed by the

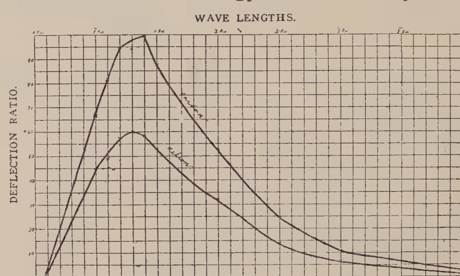


FIG. 6.

same two lamps in producing this luminosity curve. It will be noticed that the Helion energy curve is the smaller one, while the luminosity curve is much greater than the carbon filament. The greatest degree of luminosity for each lamp appears at .58 . This result seems to be due to some characteristic of the human eye, because a Welsbach mantle, the open gas flame, and other sources of illumination so far tried, all give a maximum intensity at this wave-length, and it would appear that the normal eye is most sensitive to this wave-length, which is between the yellow and the green.

Sufficient time has not yet elapsed to give conclusive life tests on these filaments, but out of the few tested, eight lamps have shown lives of from 485 hours to 1,270 hours actual burning. The lamps tested were all lamps originally made for other tests, and some of them had burned for a great many hours before being placed on the life test, and had been tested for candle-power at various consumptions, etc. All were made, mounted, enclosed in the glass bulbs, and pumped out at the laboratory where the facilities for mounting and pumping were not the best, so that this life test does not show as good results as will probably be secured on new lamps placed on life tests without being strained by the other tests to which these lamps were subjected. That the life of the lamps tested was controlled to a great extent by the previous treatment the lamps had received, the condition of the terminals, and the degree of vacuum attained, is indicated somewhat by the fact that the lamp which failed at 485 hours showed a decrease in candle-power of about 15 per cent., while the lamp which ran 1,270 hours showed a drop in candle-power of only about 3 per cent. Several of the lamps ran more than 700 hours, and a number of them showed an increase in candle-power over the initial candle-power during some portion of the life. One lamp which ran 735 hours showed a gradual increase in candle-power which reached a maximum of about 2 per cent. Each lamp in each case parted either at or near the cement terminals or anchor, which indicated either a condition of strain on the filament, or else that the cement acted upon the filament. In some cases it has been found that the cement which was being used at that time contained a low silicate, which combined with the filament and reduced its cross section near the terminal, causing the filament to part at this point. The lamp which ran 1,270 hours showed rather an interesting performance. The lamp was started at 37 watts and 37 candle-power. At the end of 200 hours it began to show an increase in candle-power, which increase continued until the candle-power reached 40 at 400 hours, the wattage remaining practically constant at 37. At 400 hours the candle-power began to decline and again crossed the 37 mark at 500 hours. The decline continued at a very slow rate, and when the last reading was taken at 1,230 hours, the illumination had dropped to about 35.5 candles, and the consumption was about 36.5 watts. This lamp failed near one of the carbon terminals at 1,270 hours of continuous operation. The only blackness or discoloration on the glass, perceptible to the eye, was a ring of brown color around the lamp near the base and opposite the terminals. From observations made up to the present time, the high efficiency of the Helion filament reaches a maximum whiteness at a comparatively low temperature, after which an increase in temperature to the 1,720° point increases the intensity of illumination, but does not appear to make very much change in the color of the light; but with a carbon filament the color and quality of the light shows a marked change as the temperature increases. In making some comparisons with the carbon filament, they were run up in temperature to the point of disintegration, but even at this point the light was very much more yellow than the Helion filament at its normal working temperature. It has been found possible to make filament as low as 30 candle-power for present commercial e. m. f. of from 100 to 115 volts, at approximately the same length as carbon filaments. How much smaller unit it will be possible to make is yet to be ascertained.

LIGHTING AND MAINTENANCE

Abstract of paper read before the London and Southern District Junior Gas Association.

The most important factor in gas lighting today is a uniform and increased pressure. I find that burners working under pressures of 3 inches and over give vastly better results in every way than under the old 15-10th conditions. Pipes can be reduced to half the size of those required for very low pressures; complaints of bad lights and stopped supplies are reduced to a minimum; the nipples will not get choked with dust so quickly; the mantle has more chance of adapting itself to the flame, and *vice versa;* and increased pressure prolongs the life of the mantle, as it becomes hardened and crisp after being burnt for a short time.

In order to give the candle efficiency as pressure increases, photometrical tests have been made with an ordinary No. 4 Kern burner; different sized nipples being used, and the burners adjusted to obtain the best results at each given pressure.

Governors for ordinary conditions should not be extensively used, as they

Pressure in Tenths.	Flow of Gas. Cubic Feet	Illuminating Power.	Average C. P. per Cubic Foot
15	4.9	90	18.3
20	5.5	103	18.7
30	5.1	100	19.6
40	5.5	120	21.8
50	6.3	143	22.7

cause complaints of bad supply, materially reduce pressures, stick, and get out of action quickly. Consumers, I find, when advised to dispense with their use, are always satisfied with the after results, though sometimes it is a very difficult matter to convince them. Regulation should take place on the consumer's premises at the burner. A governor when used to keep a uniform pressure of gas delivered from compressing plant, is certainly in its place; but to adopt it commercially means some trouble. The simplest means of checking the gas supply is at the meter-tap, or at each individual point; or a still better method is the "gas adjusting nipple." By the use of this nipple you can obtain an equal duty in every spot. In adopting the adjustable nipple, it is necessary for it to be of very fine manufacture, made perfectly true, and with a smooth edge. Better results are obtained from one that has a centre adjusting movement, because I contend that gas should impinge from the nipple in the direct centre of a Bunsen tube, and not by shutting off one, two, or three of a number of holes, as the case may require. To illustrate the value of this nipple, I fitted a No. 4 Kern burner with one, and the photometrical readings were as follows:

Pressure in Tenths.	Flow of Gas. Cubic Feet.	Illuminating Power.	Candle Power per Foot.
15	4.4	87	19.7
20	4.7	95	20.2
30	5.2	115	22.1
40	6.0	138	23.0
50	6.3	153	24.2

Comparing the above figures with those of the ordinary nipple already given, clearly proves that the adjustable nipple is going to play a very prominent part in gas lighting.

I consider the most perfect inverted burners are those of the swan-neck type, with the air chamber lower than the ignition point, as this brings it back to a very great extent to the ordinary upright, which is a more natural way of burning gas than being delivered entirely in a downward direction. There are, however, still vast improvements required to make the inverted burner an absolute success.

The Kern burner for low pressure lighting still stands supreme; and I have never come across its equal for lighting efficiency per cubic foot, though it is costly to maintain, when compared with others. Self-intensifying systems passing over 10 cubic feet of gas per hour are not desirable; but smaller lamps give very good results, particularly those of the recuperative type.

It is really a matter of experience to determine the amount of light required for a given area; but the rule of 1 candle for every 3 square feet of floor area is a very good standard to work upon assuming as a basis the room to be lighted to have a white ceiling and walls, and lights placed 9 feet high, increasing the power according to the color of the walls, decorations, or obstructions. An increase of 5 to 7½ per cent. in candle-power will usually suffice for every foot over and above 9 feet in height. The general public, to my mind, have a great tendency for increased light, which is certainly very harmful and destructive to the eyesight, especially the rays given from the electric arc. Of late, there has been a great rage to adopt the four-burner cluster lamps for inside use, ranging from 250 to 500 candle-power in one unit of light. To fix a lamp with this number of burners, for lighting shop or rooms say 14 ft. x 16 ft. x 10 ft. or 12 ft. high, is wrong, and of very little benefit to the consumer. It is infinitely better to instal cluster lamps with a less number of burners. All lights, as far as possible, should be hung from the ceiling, and every endeavor made to have the mantle suspended in a direct line with the cup and ball, so that when globes or any parts are removed for cleaning purposes the mantle is left still in the vertical. The pendants and all fittings of this class should be avoided, because according to the weight of removable parts, so the mantle is thrown out of the vertical line. This causes the mantle fringe to break, and also strains the loops and shoulders. I estimate these fittings increase the maintenance cost at least 33 per cent. The disadvantages of this class of fitting applies more to the upright than to the inverted burner, as the clay rings take up the strain. For outside shop lighting, there seems to be a great tendency for four-burner lamps. I cannot understand why. You get practically the same results with three-light lamps, reducing wear and tear and gas consumption 25 per cent., and giving the consumer more satisfaction. Cluster lamps should be used in preference to single burner, as you have always a fall-back in case of breakage of mantles.

Review of the Technical Press

AMERICAN ITEMS

STREET ILLUMINATION BY ARC LAMPS: W. E. Daniels, *Western Electrician,* January 12th.

The article deals in particular with a new method of placing arc lamps which is being tried in certain parts of Chicago. A lamp of special construction is used, which is entirely concealed within a 20-inch plain opalescent glass globe, supported at the top of a slender fluted lamp-post. The writer states that in a test about 7 lamps were used in a block of 400 feet, and a very satisfactory distribution of light was found. Shadows, light waves, dark spots, and other usual annoying features were conspicuous by their absence. The area of useful light was found to be equal to the regularly constructed lamps, and the character of light decidedly better. The article is illustrated with the 5 half-tone cuts showing old and new methods of arc light.

ILLUMINATING ENGINEERING: L. B. Marks, *Electrical Review,* January 12th.

A brief review of the subject, calling attention to some of the absurdities in lighting practise still in existence, and the necessity of studying illumination from the engineering stand-point.

RUDIMENTS OF ILLUMINATION: Dr. Louis Bell, *Electrical World,* January 5th.

In this short article, this well-known writer on Illuminating Engineering has included an extraordinary amount of "safe and sane" advice on illuminating engineering. In fact, the practician who will make himself familiar with these "rudiments," and apply them with judgment, will not go far wrong in any problem of illuminating engineering.

ELECTRIC LIGHT IN CRYPT: Henry Gutherie, *Technical World,* February.

A brief description of the illumination of the new Berlin (Germany), Cathedral.

The illumination is by the indirect method. A number of arc lamps are hidden above the cornices in the main cathedral on the galleries of the cupola, and by means of reflectors distribute the light uniformly throughout the vast hall. Other illuminants of the same kind throw their light upward from magnificent candelabra placed in the aisles. An extensive use has likewise been made of Nernst lamps, as well as incandescents; 100 of the former and nearly 2,000 of the latter being used.

A NOVEL PHOTOMETER: *The Scientific American,* Dec. 8, 1906.

The numerous attempts so far made to utilize the luminous sensitiveness of selenium for the construction of a suitable photometer have now for the first time been crowned with success, in connection with a novel selenium photometer brought out by a Mayence constructor, which is quite independent of the inertia of the selenium, the temperature of the air, and the load on the selenium cell, as well as of all other factors disturbing the sensitiveness of the selenium. The slow alteration undergone by the selenium cell in course of time is doubtless without any influence on the tests. The accuracy insured in using this apparatus greatly exceeds the accuracy afforded by any similar photometrical process, while the tests are carried out more rapidly and without any difficulty.

The novel principle used in constructing this photometer consists in throwing a selenium cell in a rapid alternation from the range of a standard lamp into the range of the lamp to be measured, the resulting current oscillations being ascertained by suitable instruments. As soon as the oscillations of an index are discontinued, the illumination produced on the cell by both of the illuminants is found to be equivalent.

The apparatus includes two mirrors lighted by the two illuminants respectively, while a selenium cell rapidly oscillating between

two given positions is lighted alternately by either. The index of an ammeter oscillates in accordance with the fluctuations in illumination thus produced, and the instrument should be displaced until these oscillations are found to cease, thus showing the equivalence of the illuminations due to either lamp, when their respective distances from the photometer will, according to a well-known rule, give the luminous intensity of the lamp to be tested in terms of the standard lamp.

As regards the influence of considerable differences in color between the two illuminants, selenium seems to behave very well with the luminous sensitiveness of the eye in regard to the same color. It thus seems likely that no errors worth mentioning will be made in practical tests, and it is surmised that the retina of our eye perceives in the same way as selenium, while such differences as have been found from time to time are attributable to the absorption of rays by the liquid and other membranes of the eye. A suitable compensation could thus be obtained by inserting in front of the selenium cell an optical medium equivalent to the substances lying in front of the retina.

A Study of Certain Shades and Globes for Electric Lights as used in Interior Illumination: By William Lincoln Smith, S. B. From the *Technology Quarterly,* Vol. XIII (Mass. Inst. of Technology).

A. GENERAL CONSIDERATIONS.

In the first part of this paper were given distribution curves of incandescent lamps fitted with various types of shades or globes, and the efficiency of the several combinations was determined by finding the Mean Spherical Candle-power and the Energy consumption in the usual manner. The Mean Spherical Candle-power is, in my opinion, the quantity by which in the last resort one must compare relative efficiencies, unless one is willing to lose himself in a maze of cross purposes and entangling specialties, among which it is exceedingly difficult to find any other simple and satisfactory basis of comparison.

Here as elsewhere, however, one must not fall into the error of making efficiency the only criterion.

There is, first, the broad and complex matter of *color effect* to be considered, since it by no means follows that because a particular effect is satisfactory in one case, it will be even bearable in another, where the same general arrangement holds, but the color scheme and character of decoration is widely different. For examination along this line we must call in the aid of the Spectro-photometer, and the corresponding section of this work is reserved for part three of this paper, the preparation of which is at present in progress.

The second point to be considered is that of *distribution of light over surfaces to be illuminated.* It is only in very rare cases that it is advisable to use modern light sources, as Welsbach mantles, acetylene gas, incandescent or arc lamps, unaccompanied by some form of diffusing shade or globe, for most frequently the source will come somewhat within the line of vision. In this case the intrinsic brilliancy must be cut down—all the newer light sources agreeing in this: that the value of the candle-power emitted per unit of area of light-giving surface is very high. Thus the open arc may give over 25,000 C. P. to the square inch, the incandescent lamp may range from 100 to 200, acetylene gas ranges from 75 to 125, while the Welsbach mantle will vary from 20 to 25. Now, of the older light sources, the flat flame of gas gives from 4 to 8; the oil lamp, from 3 to 8, both varying widely, however; and the candle is lower still. It is safe to say that the intrinsic brilliancy should never rise above five candle-power per square inch, and personally I prefer to keep it rather lower if possible.

Thus it will be seen readily that the use of some form of diffusing shade is necessary in the great majority of cases, in order that the light may appear to radiate from a much larger surface than is the case with the bare lamp, and thus the intrinsic brilliancy be properly reduced. But the shade ought to do more than this, it should aid us from the point of view of *illumination* as distinct from *lighting,* and it is just this distinction which the great majority of persons fail to take into account. For instance, let us consider a draughting room. Suppose we hang lights on pendant cords over each drawing table; the illumination of the boards will be strong and bright, yet the room may be very badly lighted. For if the lamps are fitted with conical green paper or tin shades the whole upper part of the room will be in gloom and the worker's eyes strained as he raises them from his work and then drops them again; while if the lights are bare the conditions may be as bad, if not worse; since, if the lamps are high, it will be difficult to get light enough at the proper angle on the board, and, if low, they may easily come within the range of vision. In either case the workman will find that on raising his eyes from his work they are strained, just as when the shades were used. In the first case the iris dilated to accommodate itself to the gloom of the room as compared to the board, in the second case it contracted to accommodate itself to the presence of the small, bright light sources; so that the

alternate opening and closing will finally result in serious strain, and may do irreparable damage. We get, in other words, good illumination but very bad lighting. Now suppose this room to be lighted by concealed lamps of high power, their light being thrown on to a white diffusing surface, as a slightly arched ceiling and whitened walls, the room will be excellently lighted, but the working illumination will be bad, for we shall have approached so nearly to complete diffusion and uniformity that the result will again be strain and damage to the eye, resulting in this case from the total absence of shadow and the consequent inability of the eye to readily locate a point on the paper or to judge of distance; the strain now falling upon the focusing apparatus instead of, as previously, upon the muscles controlling the iris.

Between these two extreme cases will be found a happy mean, which may be more or less closely approximated in a variety of ways. In the room considered above, it would be found in providing a moderate general illumination by the hidden lights, and fitting each table with a small, thoroughly shaded lamp, flexibly supported, so that its rays could be directed at any desired angle upon any desired portion of the work.

Such a lay-out, however, would prove decidedly expensive, and an approximation to the result might be made by the use of larger lamps raised high and fitted with globes which would cut down the intrinsic brilliancy properly, and at the same time direct the light downward, so as to give sufficient illumination.

Accordingly, it is of great importance for one to be able to determine beforehand just what a given arrangement is going to give in the way of illuminating effects. In some cases one can say off-hand that the results will be thoroughly bad. Thus, if a globe like No. 15, Part I of this paper (a globe with the top half opal and the lower half clear glass cut with a many-rayed star), be used, the result will be unsatisfactory for many purposes, because the globe will produce very marked striations on a surface below.

Again, take the case of the turnip type of incandescent lamp, with the upper half silvered. If the bottom half is clear glass, the light downward will be very intense, but the illuminated surfaces will be crossed and cut up by caustics and striations of great prominence. If, on the other hand, the lower half be frosted, the light will be much reduced (which does no great harm, because almost everyone just now is carried away by the delusion that the more powerful the illumination the better he can see than which there is no greater error), but the illuminated surface will show no trace of striations and the result will be good.

In the cases of many other globes and shades, indeed in the great majority, it is very difficult to tell just what will be the effect, even if the distribution in the mean vertical plane (found by spinning the combination) is known. Globes of the same pattern frequently vary widely among themselves, and the distribution of a given globe varies with the azimuth, so that it is altogether too laborious to attempt a calculation, with the probability in view that it will prove fallacious in the end.

It is herein, in my opinion, that one of the greatest advantages of the Holophane glass is to be found. As Part I of this paper shows, the efficiency of the globes is excellent, the light can be thrown practi-

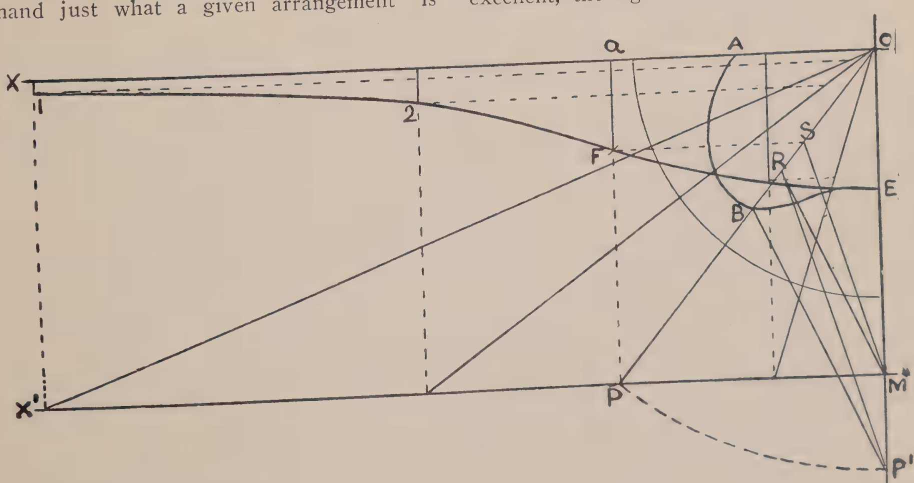


FIG. I.

cally in any desired direction, and the diffusing action is practically perfect. I think that this Part will show that they also excel in the uniformity existing among individual globes of the same type, and in the precision with which they allow the determination beforehand of the results to be attained—such precision, of course, being an important indication of scientifically correct design and careful manufacture.

B. METHOD OF DETERMINING THE ILLUMINATION ON A SURFACE.

Given a lamp having a definite distribution curve, and situated at a definite height above a horizontal plane, to determine the illumination at any point of the plane:

In Figure 1 (drawn full scale), let O be the center of the lamp having the distribution curve ABE, and let MX' be the surface, drawn at a vertical distance OM, below OX, such that $K \cdot OM =$ the distance in feet of the surface below the lamp, K being the equating constant, while the candle-power along any radius, as OP, is given by $K' \cdot OB$, OB being measured in the same units as is OM, = say in centimeters.

The intensity of illumination at the point P in the horizontal plane will be:

$$e = \frac{K' \cdot OB}{(K \cdot OP)^2} \cos QPO.$$

Now, let us lay off $OP' — OP$, join B and P', and through M draw parallel to BP', giving us point R. Connect R and P', and through M draw a parallel to RP' and we obtain a point S, and we have:

$$OS = OB \left(\frac{OM}{OP}\right)^2.$$

If through S we draw parallel to OX until we reach PQ at F, we shall have:

$$QF = OS \cos QPO = OB \left(\frac{OM}{OP}\right)^2 \cos QPO,$$

and it follows that

$$e = \frac{K'}{(K \cdot OM)^2} QF = \frac{K'}{h^2} QF,$$

h being the true height of the lamp above the plane in feet.

Continuing this process with successive radii, we obtain a curve, as 1, 2, F, E, having O as the origin, OX and OM as axes of abscissæ and ordinates respectively, such that the abscissa of any point multiplied by K gives the distance of the point from the foot of the perpendicular through the axis of the lamp, and the ordinate multiplied by K'/h^2 gives the illumination at the point in candle-feet. It is obvious that, if a given type of lamp or globe always gives the same distribution curve, the above construction gives a plot which will be suitable for any candle-power and any height of lamp, the values of the equating constants K and K' being changed to correspond. If a point receives light from more than one source, it is sufficient to sum up the illuminations received from the several sources.

In the figure, if $K = 1$, *i.e.*, if 1 cm. = 1 ft. and $K' = 5$, *i.e.*, if 1 cm. = 5 candle-power, then the height of the lamp will be 6.5 feet above the plane, the illumination at the point P, distant 5.4 *feet* from the foot of the perpendicular, will be:

$$e = \frac{K'}{h^2} QF = \frac{5}{(6.5)^2}(1.8) = 0.21 \text{ candle-feet.}$$

C. APPLICATION OF THE METHOD.

A case to which I have recently applied this method, and which furnishes a good example of its powers, is that of the New Meeting House of the First Parish in Concord, Massachusetts.

This building is illustrated in the following plates:

Fig. 2, half end elevations of the auditorium.

Fig. 3, a plan of the vestry and basement floor.

Fig. 4, a plan of the auditorium floor.

Fig. 5, a plan of the galleries.

Figs. 6 and 7, showing the auditorium looking east, illuminated by daylight and artificial light.

Figure 7 and 8, the same, looking west.

On these plans the location of the lights is indicated by round dots, and on Figs. 3 and 4 the small crosses with attached numbers indicate the stations for which the illumination was calculated when planning the installation, and at which it was afterward determined by direct measurement.

The first step in the work was to determine the total candle-power required in the auditorium. This has, allowing for the space occupied by the galleries, organ, etc., approximately 82,000 cubic feet, requiring, on the basis of 0.02 candle-power to the cubic foot, a total of 1,640 candle-power. It was intended to use twenty No. 3555, thirty-four No. 3105 and one No. 16000 Holophane globes, having absorption, respectively, of 13.8 and 12.1 per cent., while the No. 1600, which had not been measured. was assumed to have the same as the 3555's. Allowing for the relative quantities of the several globes, this gave a mean percentage of 12.7, and, accordingly, the candle-power required would be increased to 1,848, while the amount actually used was 1,862, as this divided up better, being at the same time on the safe side.

The No. 3555 is an 8-inch ball, intended for pendant use; the No. 3105 is a 6.5-inch ball, for upright use, and the No. 1600 is a two-piece 16-inch sphere, for pendant use.

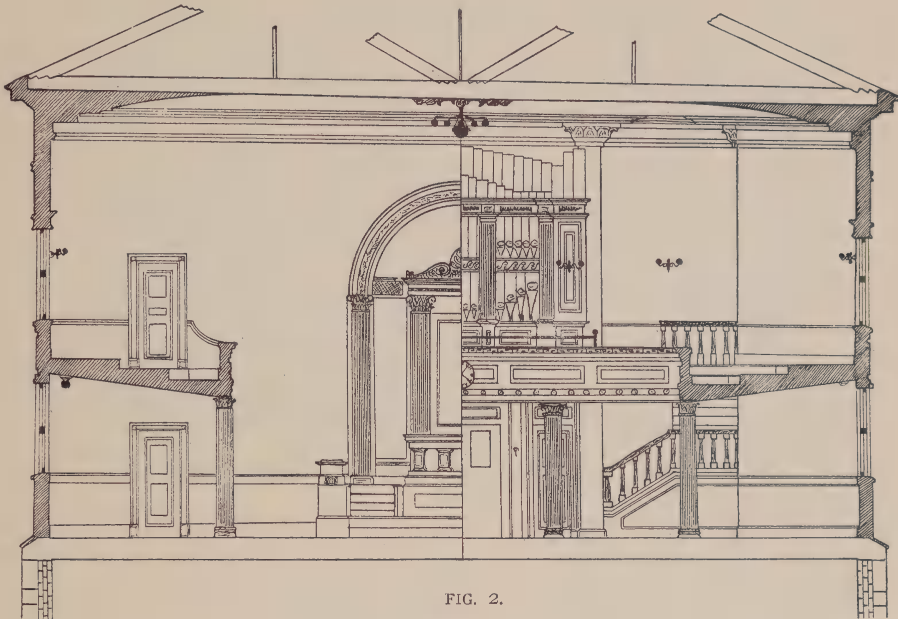


FIG. 2.

The 16-inch ball has a distribution not widely different from that of the 8-inch pendant spheres, and as but one was used, and as this one was located in the center of a cluster, it was deemed unnecessary to make a special plot.

The two illumination curves are given in Fig. 10.

The general scheme of lighting was to be—a central cluster, a row of ceiling lights on either side below the galleries, and a row of side brackets over the galleries between the windows.

In the center of the auditorium was placed the 16-inch ball containing a 150 C. P. lamp, and around it, on a radius of 3 feet, a circle of eight of the No. 3555 balls, each containing a 50 C. P. lamp, the mean

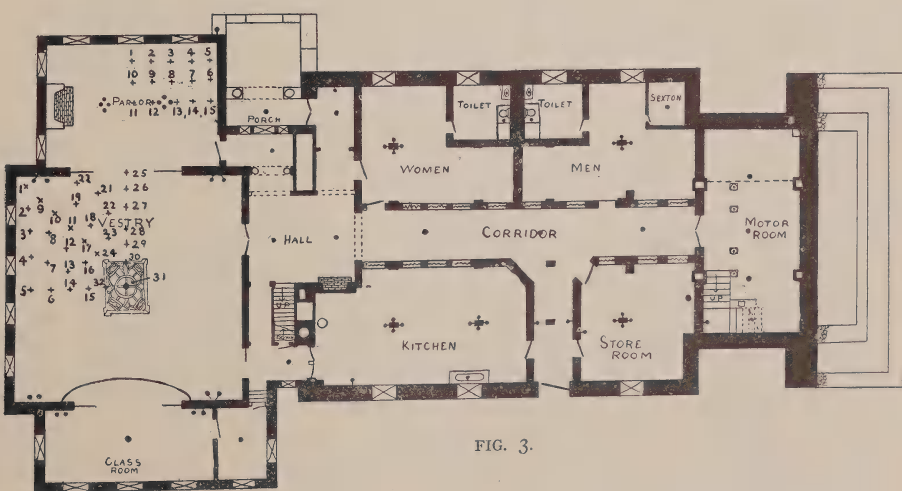


FIG. 3.

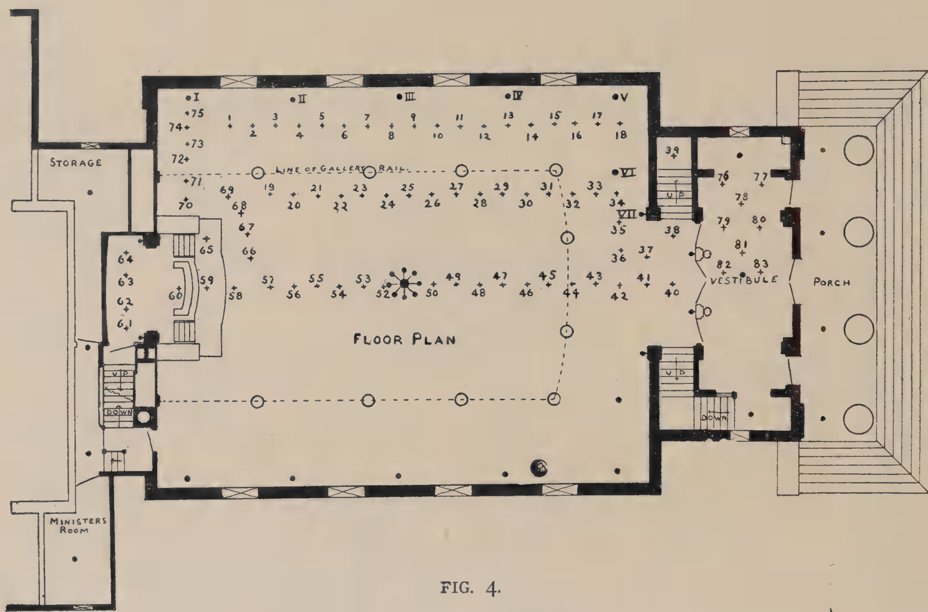


FIG. 4.

distance below the ceiling being about 3 feet.

Under the galleries, spaced midway between the windows and close against the ceiling, were placed No. 3550 balls (which are the same as No. 3555's. only fitted for a 4-inch shade holder, instead of a 5-inch), each containing a 32 C. P. lamp.

Over the galleries between the windows was placed a row of two-armed brackets, carrying No. 3105 globes with 32 C. P. lamps. The height of these brackets from the gallery floor was carefully fixed, so that the body of the auditorium was shielded, so far as possible, from the direct rays of the lights by the screen formed by the

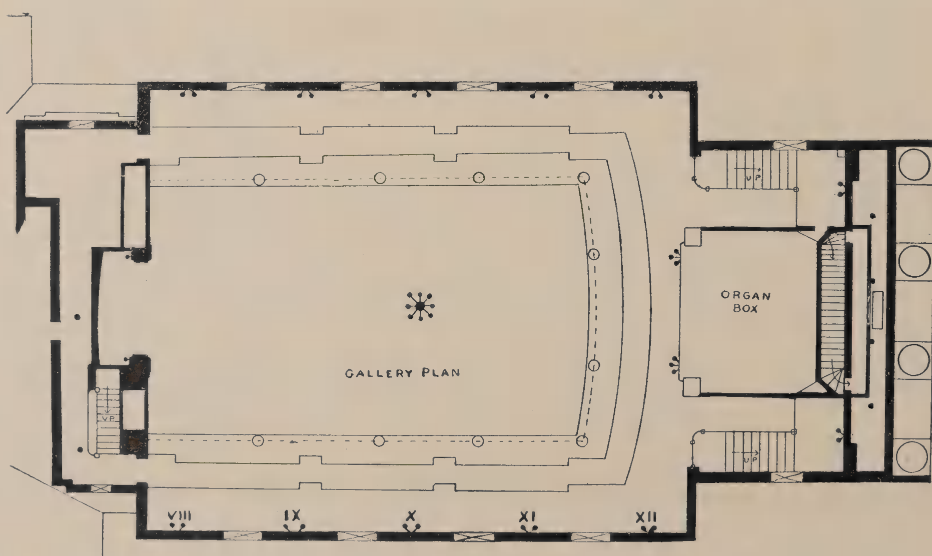
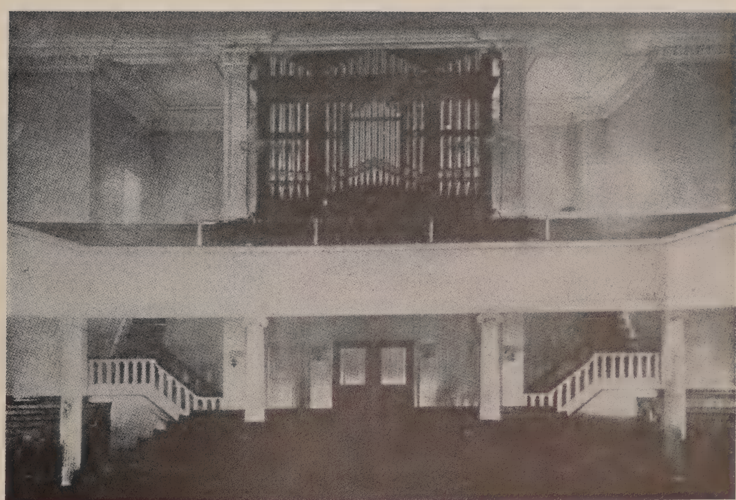


FIG. 5.

EAST END—ELECTRIC LIGHT.
FIG. 6.

gallery rail (for the center of the auditorium floor was going to be high in illumination at the best), while at the same time the rays were allowed to reach as far as possible under the opposite gallery, to assist in the illumination at that point. It is obvious that this consideration determined the height within very narrow limits; the illumination, however, came out very uniform, and far better than would have been obtained had the lamps been placed a foot and a half higher.

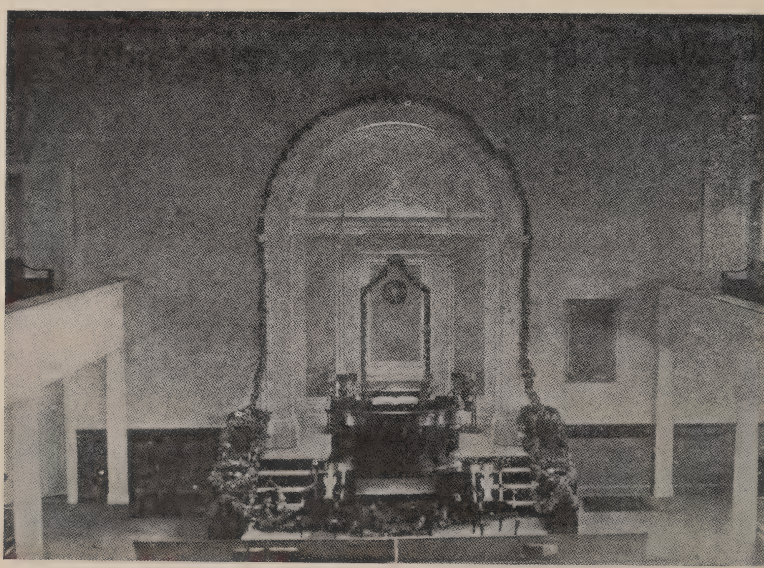
On the east wall of the building, right and left of the organ box, were placed similar brackets; on the organ front, two three-armed brackets, with similar globes and 16



EAST END—DAYLIGHT.
FIG. 7.

WEST END—ELECTRIC LIGHT.
FIG. 8.

C. P. lamps; on the posts at the foot of the gallery stairs and between the fly doors were put single armed brackets, similarly fitted; while on the ceiling under the galleries, opposite the landings of the stairs, were put No. 3550 globes, as well as along the sides, only nearer to the front of the gallery. The arch behind the pulpit was lighted with five 10 C. P. frosted lamps, wholly concealed from view, these brightening up that point but adding little to the general illumination.



WEST END—DAYLIGHT.
FIG. 9.

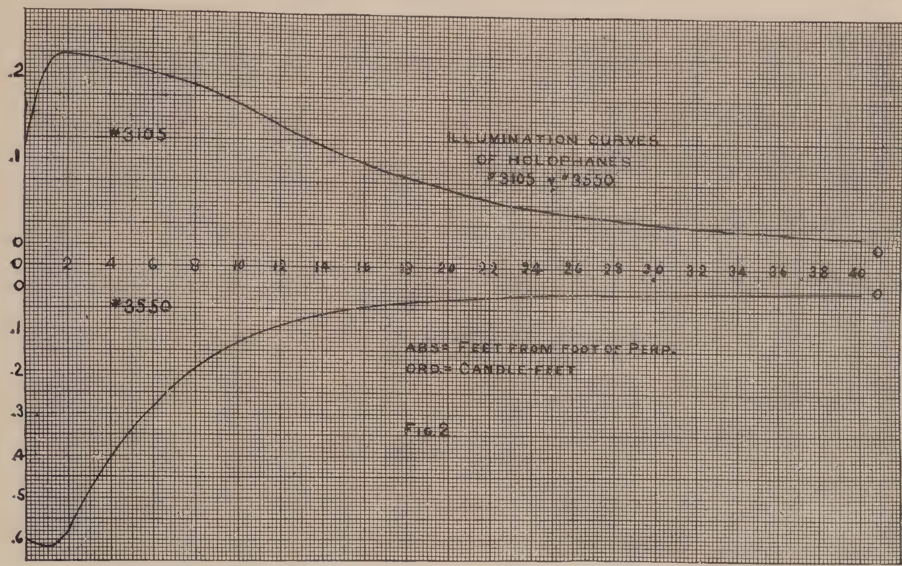


FIG. 10.

The auditorium is finished in a very delicate blue tint on float-scoured plastering. The ceiling is slightly curved, finished to a light cream, the cornice white, and all woodwork and trimmings white. Behind the pulpit the finish is gold leaf, with a matt surface and white trimmings, so that the only dark portions are the blue carpet, the California red-wood pews, and the mahogany pulpit and organ case at opposite ends of the auditorium.

Some careful measurements upon finish of this nature indicated that one might safely count on an increase of about seventy-five per cent. over the calculated illumination due to diffuse reflection.

A surface upon which to lay out the illumination was now chosen at 4 feet above the floor, that being about the average height of hymn books during singing by the congregation.

Several typical points were now chosen, the lights affecting these carefully located on the building plans (though no light more than 50 feet away was considered), the distances measured, and the illumination determined. The location of the lights was then changed somewhat and the calculation repeated, the location finally chosen being that which on the average turned out best; it being decided to keep, so far as possible, between the values of 1.0 and 1.5 candle-feet.

Thus, suppose we consider Station 9, which is shown on Fig. 4; the lamps affecting this are shown marked with Roman numerals on Figs. 4 and 5. Table I shows the final estimate.

TABLE I.

Lamp No.	Distance in feet from foot of perpendicular.	Illumination in candle-feet.
1	29.0	.0045
2	15.5	.0525
3	3.0	.4800
4	11.0	.1100
5	24.5	.0200
6	Shaded	.0000
7	30.0	.0200
8	52.0	....
9	45.0	.0090
10	44.00	.0100
11	45.0	.0090
12	49.0	.0050

The illumination sums up to 0.72 candle-feet. Increase this by 75 per cent., and it is 1.26 candle-feet, a number fairly within our limits.

It was found afterward by measurement that at this station the actual illumination was 1.24 candle-feet, a difference of less than 2 per cent. This, I may add, is an exceptionally good point.

When this exact location for the lights had been determined, large scale plots of the illumination curves were made, and the illumination at seventy-five stations was calculated, to be sure that no serious discrepancies had crept in. These seventy-five stations were all on one side of the auditorium, it being assumed that the other side would be symmetrical with the first.

D. MEASUREMENT OF THE ILLUMINATION.

For the determination of the illumination obtained, I used a Leonhard Weber Port-

able Photometer. The white card supplied by the makers was used and no opal screen was inserted, as it was possible to get readings without one. Instead of the benzine standard belonging to the instrument, a small incandescent lamp was used. This lamp had been aged and was run at considerably less than its rated voltage, being supplied from a good-sized storage battery of three cells. The voltage on the lamp was 3.50, being maintained constant by the aid of a suitable, finely divided resistance and a carefully calibrated Weston voltmeter. This secondary standard was calibrated against a Hefner Standard lamp and a curve (Figure 11) drawn giving directly the illumination on the white card in terms of the graduated scale on the Photometer. Because of the color difference between the Hefner and incandescent lamps, it was found necessary to use the red and green diaphragms in the eyepiece during calibration, but for all the rest of the work the colors were so nearly alike that the clear eyepiece was entirely satisfactory. Table II gives the values found during calibration.

When in use the photometer was mounted on a tripod and fitted with a swinging arm, so that the white card could always be brought into the same position with reference to the photometer. Settings could be made with rapidity and ease, in every case a series of settings being made and the mean recorded. The principal difficulty found was in getting the card and photometer into the proper relative positions without shading the card from the light of some one of the nearer lamps, but in the great majority of cases this was accomplished finally. At Stations 19, 23, 27, 28, and 31, however, there was a certain small shading effect which was found unavoidable.

Table III gives a summary of the results. The first column gives the number of the station, the second the calculated illumination, the third the same quantity as measured, and the last the percentage difference between them.

TABLE II.

Scale reading in mms.	Illumination on Card. Before test.	After test.
80	3.28	3.25
90	2.58	2.60
100	2.10	2.11
110	1.73	1.70
120	1.45	1.43
130	1.25	1.28
140	1.07	1.04
150	.930	.900
160	.822	.817
170	.731	.735
180	.654	.649
190	.580	.577
200	.523	.520

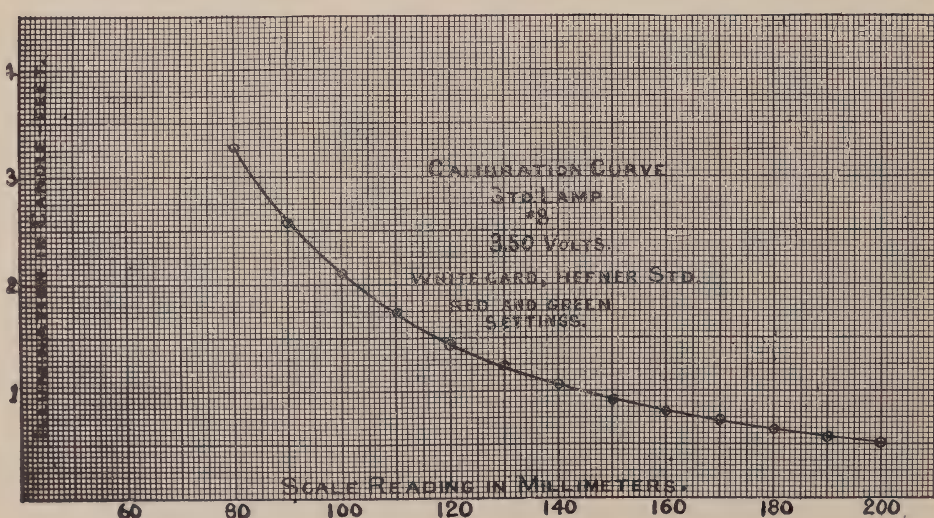


FIG. 11.

TABLE III.

No. of station	Illumination as Calculated	Illumination as Measured	Per cent. difference	No. of station	Illumination as Calculated	Illumination as Measured	Per cent difference
1	0.79	0.75	5.0	43	1.30	1.32	1.5
2	1.03	0.98	5.0	44	1.20	1.24	3.2
3	1.08	1.10	1.8	45	1.17	1.20	2.5
4	1.26	1.27	0.8	46	1.15	1.12	2.7
5	1.10	1.00	10.0	47	1.22	1.26	3.2
6	0.98	1.00	2.0	48	1.31	1.38	5.1
7	1.12	1.00	12.0	49	1.58	1.49	6.0
8	1.14	1.14	0.0	50	1.50	1.56	3.8
9	1.26	1.24	1.6	51	1.61	1.69	5.0
10	1.23	1.18	2.8	52	1.51	1.56	3.2
11	1.08	1.04	3.8	53	1.54	1.50	2.7
12	1.17	1.10	6.4	54	1.40	1.44	2.8
13	1.29	1.32	2.3	55	1.32	1.39	5.0
14	1.21	1.19	1.7	56	1.20	1.26	3.2
15	1.12	1.16	3.5	57	1.10	1.12	1.8
16	1.36	1.24	9.7	58	0.80	0.90	11.1
17	1.45	1.47	1.4	59	0.79	0.95	16.8
18	1.46	1.52	4.0	60	0.97	1.20	19.2
19	1.09	1.00	9.0	61	0.88	1.18	25.4
20	1.16	1.20	3.3	62	0.85	1.16	25.9
21	1.12	1.17	4.3	63	0.84	1.17	27.2
22	1.00	1.05	4.8	64	0.89	1.17	23.9
23	1.03	0.97	6.2	65	0.85	0.99	14.1
24	1.23	1.19	3.4	66	0.97	1.10	11.8
25	1.32	1.29	2.3	67	0.93	1.05	11.4
26	1.26	1.20	5.0	68	0.98	1.09	10.1
27	1.15	1.06	8.5	69	1.04	1.11	6.3
28	1.06	0.98	8.1	70	0.82	0.90	8.9
29	1.06	1.05	0.9	71	0.90	0.96	6.3
30	1.13	1.11	1.8	72	0.70	0.75	6.6
31	1.13	1.09	8.3	73	0.70	0.80	12.5
32	1.16	1.07	8.4	74	1.00	1.00	0.0
33	1.20	1.25	4.0	75	1.10	1.20	8.3
34	1.26	1.35	6.7	76	0.80	0.86	7.0
35	1.28	1.36	5.9	77	0.82	0.87	5.8
36	1.27	1.21	5.0	78	0.86	0.77	11.7
37	1.14	1.20	5.0	79	0.72	0.81	11.1
38	1.03	1.08	4.6	80	0.91	0.80	13.8
39	1.00	0.95	5.3	81	0.95	0.97	2.1
40	1.20	1.25	4.0	82	1.13	1.10	2.7
41	1.34	1.31	2.3	83	1.10	1.09	0.9
42	1.36	1.30	4.6				

E. DISCUSSION OF RESULTS.

In this table the mean value of the percentage difference between measured and calculated values is 6.6 per cent., the maximum being 27.2 per cent. and the minimum 0.0 per cent. There are, however, only seventeen stations where the difference exceeds 10 per cent., and many of these can be readily accounted for. Thus, Stations 58 to 68, inclusive, are those where the greatest difference exists, and these are the very ones which are most affected by the five small hidden lamps behind the arch, back of the pulpit, the effect of which was not taken into account in the calculation; as their exact location depended upon the detail of the plaster and *papier-maché* work, which was not at hand till long after the calculations were made. These lamps seriously affect points 60, 61, 62, 63 and 64, and I, of course, relied upon them to bring up the illumination where it belonged; but I doubt if they would have had a large effect upon the remainder of the group, and doubtless some others, had it not been for the large amount of *gold leaf* used behind the pulpit, which was an after thought, not put on until almost the last moment before dedication, and the reflection of which I know to be large, but which naturally was not allowed for. I have not thought it wise to recalculate these points, as it is interesting to see what sort of an effect will arise from such changes.

Again, Stations 76 to 83 are in the vestibule, where the tint on the walls is *buff*. In this case no allowance for reflection was made, as the tint was a late decision. I imagine that 78, 79, and 80 are more affected, because they are at those points where the diffuse reflection is proportionately greater. Stations 81, 82, and 83 are fairly close under the dish in the centre of the ceiling, and 76 and 77, to the

ball in the alcove. If we omit Stations 58 to 68, inclusive, the percentage difference falls from 6.6 per cent. to 4.8 per cent., and the maximum difference will be 13.8 (this being one of the vestibule stations).

There are, as calculated, twelve stations where the illumination falls under our lower limit, because of shading by columns, etc. (this omits Stations 60, 61, 62, 63 and 64, for the reason noted above, and all stations beyond 75, because the same limits were not there imposed as in the auditorium), and four which rise above the upper limit.

The measurements give similarly twelve falling under and three rising above.

The mean value as calculated, again omitting the same points, is 1.16 candle-power, while by the measurements it is 1.17.

As calculated, the highest value is 1.61, the lowest 0.70; while by the measurements the highest one is 1.69; the lowest, 0.75.

In view of this, I think it fair to say that where the value of the reflection coefficient is fairly well known, and where this type of shade is used, one can, with careful work, come within about 6 per cent. of his calculations.

Figure B shows a number of stations marked in the vestry and parlor. The vestry has an arched ceiling. It is finished with green walls, float-scoured, and with red-oak wainscot, doors, and trimmings.

I would like to have lighted this by concealed lamps behind the cornice (which just shows on Plate I), but it was not deemed best. It is lighted by a 150 C.-P. lamp in a 14-inch Holophane ball, hung in the centre of the ceiling, and four two-branch side brackets on the walls, as shown, fitted with 32 C.-P. lamps and No. 3105 globes. No calculations were made for this room (except candle-power per cubic foot, which was made to have a value of .022). The measurements at the marked points give a mean value of 2.1 candle-feet, ranging between a maximum under the ball of 2.29, to a minimum of 1.88 on the diagonal midway between ball and corner of the room.

Calculation of a number of points seems to show a value of diffuse reflection from the walls of about 35 to 40 per cent.

Similarly in the parlor, which is finished with terra cotta walls—white, flat ceiling and white trimmings—the folding doors being paneled with tapestry, the mean illumination on the floor at the marked points is 2.25 candle-feet (produced by two ceiling clusters of four 16 candle-power lamps each, fitted with pendant 6½-inch Holophane, Class B, balls), and a calculation of the illumination at a number of points suggests a value of diffuse reflection of about 45 per cent.

In neither of these rooms was it thought worth while to design the illumination with the care used in the case of the main auditorium, and higher values were allowed because the varied uses of the two rooms made a stronger illumination at times desirable.

In another case a hall was to be lighted, the location of the lights being fixed by the wiring, which was already in place; but it was desired to improve the illumination, which was rather poor; due to the facts—first, that the lamps, which originally were simply frosted bulbs, did not distribute in the proper manner; and second, that the candle-power per cubic foot was low. The hall is approximately 48′ x 60′ x 24′ high; it is used for public meetings, dances, lectures, theatrical and other entertainments, etc. The lamps were arranged in a line around the sides of the hall, on the ceiling close to the walls, and in the center of the ceiling was placed a circle of twelve lights, the lamps hanging about 3 feet down. Under these conditions the effect was something as follows—there was a marked bright spot in the center, and the illumination fell off gradually toward the walls, in no place being over .85 candle-foot, and the average being about .65 candle-foot. The change made was to replace the side lights by clear bulbs; to make the central ring double the diameter of the original (or 18′), and to put clear glass, 50 candle-power lamps there. This done, the side lamps were then fitted alternately with Holophane stalactites, No. 3150 (throwing the maximum light off at 45°) and No. 3350 (throwing it directly downward), while the central ring was fitted with dishes of similarly alternate action. The result was that the illumination was raised to a mean value of 2.00 candle-feet, the maximum found (out of seventy-five equi-distant points) being 2.12, and the minimum being 1.92.

It is just as easy to calculate what the result will be in simple cases, using opal globes, ground glass balls, etc., as with Holophanes, because the distribution curves are similar in different azimuths; but it is not so simple to calculate and produce a given scheme, because one does not have the same effective method of producing various distribution curves in the same character of globe, and of combining these according to necessities of the case. Similarly, one can by many types of reflectors produce distribution curves as desired, but diffusion is either absent or imperfect; and in many cases the distribution curves differ in different shades and in different azimuths in the same shade, so that each shade strictly ought to be adjusted to exactly the desired position and then always returned to the same. With the Holophanes all this difficulty is avoided.

FOREIGN ITEMS

EXPERIMENTS ON CARBON, OSMIUM, AND TANTALUM LAMPS

BY J. T. MORRIS.

From *The Electrician*, London, Dec. 14, 1906.

The experiments described below were undertaken with the object of ascertaining how variation of voltage affects the candle-power and efficiency of certain recent types of filament lamps. The Paper is divided into three sections: Part I., Effect of Voltage Variation when Lamps are Supplied with Direct Current; Part II., Instantaneous Variation of Candle-power when Lamps are supplied with Alternate Currents; Part III., Ratio of Mean Spherical to Mean Horizontal Candle-power, Luminous Efficiency and Life.

The lamps submitted to the tests were carbon, osmium and tantalum lamps. It should be borne in mind in considering the results obtained that these must be accepted with a certain amount of caution, on account of the fact that in most cases only one lamp was tested.

The practical outcome of these tests is that for an ordinary carbon filament lamp, as is well known, a rise in pressure of 1 per cent. means a rise in candle-power of from 6 to 7 per cent., whilst with the osmium lamp 1 per cent. in voltage means 4½ per cent. in candle-power, and with the tantalum lamp a corresponding change in voltage gives 4⅓ per cent. change in candle-power. In the case of the relation of watts expended to candle-power, for carbon filament lamps the candle-power varies as the cube of the watts, whilst with the tantalum lamp it varies as the 2½th power of the watts.

A fact that has not received much attention is the effect that metallic filament lamps will have on a machine running on a lighting load. If for any reason the pressure fails and the whole load is swithed on again at full voltage (the normal current being, say, 100 amperes), then the momentary current on closing the switch will be for carbon filament lamps 50 to 60 amperes, whilst for tantalum lamps 630 amperes, and for osmium about 790 amperes. Doubtless these effects are largely diminished by the inductance of the circuits, but with a metallic filament lamp load the effect should be plainly noticeable in the increased sparking at the brushes of the generator, not to mention at the switch contacts.

The filaments of the lamps tested were examined with a view to obtaining their dimensions. The diameters were measured by means of a fairly powerful microscope, and these measurements were afterward checked by the use of a micrometer gauge.

It was found that for carbon lamps working at 110 and 220 volts, as well as for tantalum lamps, the mean spherical candle-power per square centimeter of surface is between 13 and 25.

Considerations affecting the Life of Filament Lamps.—It is an interesting fact that for thin filament lamps working at low frequencies the mean candle-power obtained from a lamp on a direct voltage is not necessarily the same as the mean candle-power of the same lamp running on an alternate voltage of the same root mean square value.

At a frequency of 30 cycles per second on alternating current the tantalum lamp gave no measurable change in candle-power from the result obtained for direct current, while the 5 c.-p. 220-volt carbon filament lamp gave about 2 per cent. increase. At a frequency, however, of 60 cycles there was no appreciable change in candle-power in passing from direct to alternating current. A Duddell-Mather wattmeter in connection with an anti-capacity non-inductive resistance was used to ensure that the same *power* was supplied in both cases for each lamp. In the case of the 5 c.-p. 220-volt carbon filament lamp under the above conditions it is worthy of note that the voltage on the alternating-current circuit was about ¼ per cent. lower than on direct current, and therefore if the test were carried out at constant *voltage* the probable change in candle-power in passing from direct current to alternating current would be about 3 per cent.

It has been stated by Robertson, amongst others, that a carbon lamp lasts longer on an alternating circuit than on a direct circuit of the same voltage. This effect has hitherto been ascribed to the same cause as the effect noticed by Kelvin on direct current—that the lamp lasts longer if the polarity is often changed. A certain proportion of the former effect, however, can be accounted for by the candle-power fluctuations and the relations existing between life and efficiency. For example, in the case of the 220-volt 5 c.-p. carbon lamp run at a frequency of 30 cycles, we get:

1. Assuming candle-power variation to be a sine wave of amplitude, that life varies as $(\text{c. p.})^{-\frac{8}{3}}$, and that mean candle-power is unchanged—theoretically, life on alternate current is 1.3 times life on direct current.

2. Assuming candle-power variation to be as obtained, and making other assumptions as above—theoretically, life on

alternate current=1.4 times life on direct current.

As no reliable figures are published giving the law connecting efficiency and life for tantalum lamps, the magnitude of this theoretical alteration of life has not been worked out; but it is fairly clear that it would be an increase, provided, of course, that the maximum temperature attained during one cycle is not sufficient to melt the filament. This being so, it is at first sight rather remarkable that a decided increase in life should be noticed when the tantalum lamp is run on an alternating-current circuit. When we consider, however, how near the filament at normal voltage is to its melting point, and also bear in mind that it is alternately heating and cooling (this alternation takes place at twice the frequency of supply) and that consequently it is subjected to repeated stresses, it is possible that part of the decrease in life is due to this, and resembles the breaking of a bar by the repetition of small stresses well within the elastic limit.

The tantalum filament apparently expands a fair amount when it is heated to its normal temperature, and this expansion causes the lamp to emit a sound immediately on switching into circuit, the noise being due to the filament moving over the wire supports.

After burning for some time the filament changes its nature and becomes, as is well known, more crystalline. When new it appears as a straight parallel sided wire, but after burning for some time it assumes a more or less disjointed appearance, as if it had been cut into very small pieces and these pieces had been fitted together without proper alignment.

These results would seem to indicate that one direction in which an increase in the life of the tantalum lamp could be obtained when used with alternating currents would be in giving greater freedom to the filament—if feasible, a freedom similar to that which the filament of the ordinary carbon lamp possesses. Possibly it might be found to answer the purpose to replace the usual zigzag of *straight* filament by a corresponding arrangement made from a piece of tantalum wire previously wound in a *very fine spiral.* The author is unaware whether this arrangement has already been tried or not; it is merely thrown out as a suggestion, as the experimental results seem to indicate that this might be a partial remedy.

THE HARRISON UNIVERSAL PHOTOMETER

From *The Electrical Times,* London, Dec. 27, 1906.

The accompanying diagram shows the arrangement of Mr. Haydn Harrison's portable photometer, which was referred to in last week's issue. The instrument is very similar in design to that devised by Messrs. Preece and Trotter, with the exception that it is provided with a flicker head, on the Whitman principle, and, therefore, is suitable for measuring light of a color differing considerably from the standard lamp. In order to make the instrument portable and compact the photometer bar and sliding lamp are replaced by a reflecting screen, the angle of which is varied.

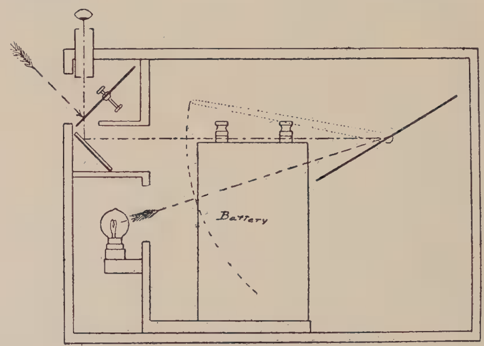


DIAGRAM OF THE HARRISON PHOTOMETER.

The component parts of this instrument and their general arrangement will be seen at once in the diagram without the necessity of refernce letters. They are a flicker head, which includes a sector in the form of a disc driven by an air blast; a reflecting screen attached to a pointer, which gives it the necessary angular motion and indicates the angle; a mirror by which the degree of illumination of the screen can be observed through the telescope; a battery; and a standard lamp. Not shown in the diagram are a plug key for connecting the standard lamp, and a sliding resistance for adjusting the instrument, should the standard lamp change or a new one be required. A tripod stand is provided to bring the instrument to a convenient height for making the measurements, and a spirit level, lens and quadrant for ascertaining the angle of incidence of the light rays. The total weight of the instrument is 18 ℔ with the stand, 15 ℔ without, and the dimensions, excluding the stand, are 13 inches by 9 inches by 6 inches. The general air of the thing is something that of a small photographic camera shut up close.

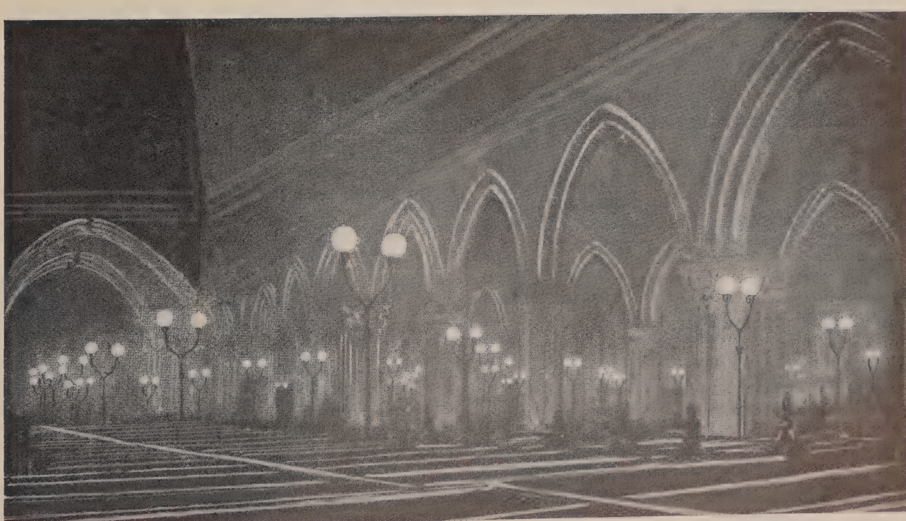
The scale is calibrated in candle-feet, and the instrument is therefore an illumination meter. To use it as a photometer one has only to measure in feet the distance of the light observed and square that number. It is this point that makes the instrument suitable for measuring any and every lamp it meets. The scale has a tenfold range, and to attack a glow lamp the instrument

is set down about 10 feet off it, while for arcs one would keep from 30 to 60 feet off, according to what they looked like. Having set up the instrument, all that is necessary is to rotate the sector disc by means of an air pressure bulb provided. The standard lamp, having been lighted by inserting the plug, the pointer can be moved until the position is arrived at, when the operator, looking through the telescope, can see no flicker. The pointer will then read the illumination in candle-feet at that distance from the light, and the candle power is then obtained by multiplying the figure read by the square of the distance in feet. The only correction required will be due to the lamp being (usually) not level with but above the photometer. For this purpose the angle of incidence is measured by the lens and quadrant attached, but this correction need not generally be taken into consideration, if the angle does not exceed 25 degrees; and the correction is scheduled on the scale, and, therefore, does not entail much trouble in any event. The designer says that the instrument is accurate to within 5 per cent. It is to be put on the market at once by Elliott Brothers at ten guineas.

GAS LIGHTING IN YARMOUTH PARISH CHURCH

From *Journal of Gas Lighting*, London, Dec. 18, 1906.

In the *Journal* for the 28th of August, we quoted from a local paper some appreciative remarks as to the improvement which was then being effected in the lighting of the Parish Church at Great Yarmouth, by the substitution of the incandescent gas system for the flat-flame burners previously in use. The work was placed in the hands of the Gas Company, and it has now been completed under the personal supervision of Mr. Charles Ellis, the Superintendent of the Distributing Department. The church is the largest in the United Kingdom, measuring 230 feet in length, 110 feet in breadth, and 148 feet across the transepts, and though the neighboring cathedral at Norwich, which owes its existence to the same founder (Bishop Herbert de Losinga) exceeds it in total length by about 180 feet, it is only 72 feet in breadth, while the measurement across the transept is but 30 feet more than the church. It will be seen, therefore, that Mr. Ellis had an unusually large interior—an area of no less than 23,265 square feet to deal with; and some idea may be formed from the accompanying photograph as to the effect of his labors. As mentioned in the August issue, the standards, which have been cleaned, lacquered, re-polished, and rearranged, have four branches, two of which carry incandescent burners, and the others flat-flame burners to be used as auxiliaries. The incandescent burners are No. 4 Welsbach Kern, fitted with anti-vibrators, and enclosed in obscured globes. There are altogether 110 of them, and they take the place of about 300 flat-flame burners consuming, on an average, 6 cubic feet of gas per burner. Their combined illuminating power is upwards of 10,000 candles with a greatly reduced consumption of gas. We have not had an opportunity of judging of the effect, but we learn from a local paper that the light produced is a "beautifully soft and restful one," that



the manner in which it is modified at times during the service is most satisfactory, and that the Church Council are very pleased with the result. It only remains to say that the photograph reproduced was the result of an exposure of only four minutes, owing to the intensity of the light. The grand old church of St. Nicholas, Great Yarmouth, which has a life-history of about 800 years, may now claim to be not only one of the largest, but also one of the best lighted of our English parish churches; and all who have been associated with the latest improvement in the fabric—the Church Council for initiating it, and Mr. Ellis and Messrs. Hulett for so effectively carrying it out—are to be heartily congratulated upon the outcome of their combined efforts.

INDIRECT ILLUMINATION

By E. Schilling, Munich.

From the *Journal für Gasbeteuchtung*, December 8, 1906.

Again some new tests of indirect illumination have made their appearance. Prof. L. Weber, of Kiel, on Aug. 30 and 31 of this year made measurements of a trial installation of indirect incandescent gas illumination in a small furnished room of the Physical Institute of the firm of Julius Hardt, of Hamburg, which have determined anew the advantages of indirect illumination and the cheapness of gas lighting.

The illumination of a room 5.8 by 4.8 by 4.18m was effected indirectly by a lamp in the center of a white ceiling fitted with two Hardt incandescent gas lamps, which had a horizontal intensity of 115.8 and 143.5 HK, or a total of 259.3 HK, with a gas consumption of 156 to 170 liters, a total of 326 liters. The center of the light source was 60cm below the ceiling. The measurements were made 1.1m above the floor, with lamps having various kinds of reflectors, and gave the following intensities:

	Under the lamp.	In the corner
Without reflector	29.6 Lux	26.3 Lux
With reflector of white japanned sheet metal reflecting above	32.7 "	23.2 "
Reflector covered with mirror plates	37.8 "	27.6 "

With opal glass there was a little improvement over the white japanned plate reflector of possibly 5%.

The intensity in the space under the lamps in the case of the half distributed illumination by means of the hemispherical opal glass shade was just as advantageous as the most favorable arrangement of the metal reflector.

Weber remarks at this point: "It was shown in this connection at once, that under the given conditions the reflector necessary for indirect illumination by no means decreased the illumination, but rather increased it, as compared with that from bare lamps. This latter is explained by the fact, that in the case of a bare lamp a large part of the rays proceeding directly from the lamp fall on dark surfaces, such as the floor and dark walls, and consequently a great deal of illumination is lost, while the dazzling white screen throws all these rays on the white wall, and thereby increases all the light falling vertically. The hygienic advantage of a lamp which does not dazzle the eye is obtained with fear of decreasing the intensity at the height of the table. This will also be the case when the walls are somewhat less white.

The measurements taken in the use of the white japanned metal reflector gave a mean horizontal intensity of 30 Lux for a 326 liter gas consumption. In a floor space of 27.8 sq. m., 9.3 HK with 11.73 liters gas consumption were necessary per sq. m., in order to produce 30 Lux 1.1m above the floor.

Weber compares the cost of gas consumption with that of the current consumption in the Bremen laboratory. In that case the currrent consumption, estimated for a similar intensity of 30 Lux, showed 13.3 watts for 1 sq. m floor space (the walls of the testing rooms being entirely white).

At a gas price of 20 Pf and a current price of 50 Pf, the cost of electric illumination with Tantalum lamps amounts to $\frac{13.3}{17.73} \div \frac{50}{20} = 2.8$ times that of the gas illumination in question.

Weber takes up the Munich tests by way of comparison, and comes to the conclusion that the efficiency of the gas consumption in the room of the Technical High School in Munich may be possibly 2½ times less than his measurements mentioned here. But Weber, regardless of the incorrect estimate already referred to, goes upon the erroneous supposition that the intensities were measured in Munich in red and were multiplied by the factor 2.5. As is explicitly noted in the report on the Munich tests, all the measurements were made in white with the aid of the frosted glass disc of the instrument when the telescope was directed perpendicularly.

The gas consumption, which produced an intensity of 88.47 Lux in the room of the Munich Technical High School, whose dimensions were 150 sq. m by 4. 8 m in

height, was 5746 liters, and therefore for 30 Lux and 1 sq. m floor space $\frac{150 \times 88.47}{5746 \times 30}$ = 13 liters, thus not essentially differing from Weber's measurements, in spite of the entirely different conditions of the experiment.

The favorable result of the Munich experiments, which have been confirmed by Prof. Roth, in Zurich, has been emphasized anew by Weber, in that the efficiency of gas consumption in indirect illumination is about 2.8 times than of tantalum lamps. Reibmayr has worked on illumination by direct light from sources placed high.

Electric incandescent lamps, having oval reflectors of transparent ribbed glass, are placed directly beneath the ceiling, and distributed uniformly over it. Measurements were made with the Weber photometer, and included the determination of the intensity as well as the distribution. The measurements were made with the incandescent lamps of 16 and 32 HK. Unfortunately, no measurements were taken in this test of the current consumption, so that no statement can be made of the efficiency of this arrangement. The measurements, which were made of the waste of light in both direct and indirect illumination, show that the waste of light which occurred in the indirect illumination by the wider distribution and by the absorption of the side walls, is much less in the direct lighting. The intensity of indirect light has been lessened on an average about 31.1% in the comparative measurements taken. If, on the other hand, a stronger shadow were expected, then the tests in question show that the direct light from the ceiling is not inferior to the indirect light either in respect to the light distribution or the shadow effect.

The following table shows a very clear comparison of the most important results of the tests.

Test Rooms	Total Intensity	Intensity in Lux			Angle of	Waste of Light by shadows		
		Mean	Maximum	Minimum	Distribution	Mean	Maximum	Minimum
Chemical laboratory 68 sq. m, 4.1 m high								
(a) High light 32c incandescent lamps	32.12 = 384 HK	34.4	38.8	26.1	67	9.8	33.0	4.0
(b) High light 10c incandescent lamps	10.12 = 120 HK	13.6	15.9	11.2	70	..	..	..
(c) Indirect illumination 32c incandescent lamps	32.12 = 384 HK	25.7	29.5	21.6	73	9.1	27.3	1.5
(d) Chandelier illumination 16c incandescent lamps	16. 8 = 128 HK	13.6	26.5	7.0	27	23.9	67.1	10.0
Room in Magistrate's building with dark, wainscoted walls (35. 8 sq. m, 3.5 m high.)	1.50 HK, 4.32 HK = 178HK	13.2	22.9	4.5	20	43.5	..	..
Small class room (51 sq. m, 3.7 m high) Indirect Illumination with the Welsbach incandescent gas light	6 Welsbach	31.8	45.3	21.0	45	10.7	17.5	3.9
Large class room (90 sq. m, 3.7 m high) Indirect illumination with the Welsbach incandescent gas light	12 Welsbach	23.9	30.9	16.3	53	12.5	15.9	5.3
Class drawing room (104 sq. m, 3.7 m high) Indirect illumination with the Welsbach incandescent gas light	20 Welsbach	32.0	42.2	18.0	43	17.3	29.0	2.5

Reibmayr summarized the results of his investigations as follows: By direct light from ceiling fixtures an illumination answering all hygienic requirements may be obtained which is especially adapted to the particular needs of school rooms, auditoriums, class drawing rooms, etc., since:

1. By this method an illuminating effect is obtained commensurate with the quality of light used. The illuminating power obtained remains constant, especially with the larger installations of incandescent lamps.

2. The distribution may be considered satisfactory, being inferior in no way to diffused indirect illumination. The room is lighted equally in all its parts; there are no unpleasant contrasts, and no light-source in a position disturbing to the vision.

3. The loss of light by shadows is small, and the shadows presented are not at all troublesome, since they are faint, and there is a very gradual change from the darkest shadow to full illumination.

4. Glare, and the effect of radiated heat are prevented by the height of the light-sources. The light-sources lie entirely out of the line of vision.

5. In the particular case of the electric incandescent light there is no contamination of the air, and no excessive radiation of heat. The electric light has the advantage of being switched on or off quietly, easily, and satisfactorily, which makes this method of illumination especially desirable.

6. This method of illumination has both a decorative and aesthetic effect (Rubner), because produced by a number of small light-sources.

The writer further expresses his opinion that the intense white of the ceiling, and the frequent necessity for whitewashing it, may not be as necessary as in the indirect method illumination. This saving, in connection with the lesser amount of light necessary for a specified illuminating effect, quite balances the higher price of direct illumination by the incandescent electric light placed high. From the foregoing erroneous investigations by Weber, it would appear that there would have to be spent for direct electric illumination with Tantalum lamps almost double the cost of indirect illumination by gas, whereas there should be assumed to be a saving of 31% over indirect illumination.

In conclusion, Reibmayr draws attention to the fact that a similar direct illumination from above may be had with an inverted gas light. From the superior efficiency and distribution of this light there are obtained certain further advantages with gas illumination in connection with the saving of gas by placing the lamps near the ceiling. It would be of the greatest interest if there were published, in addition to these notes of this personal view of the writer, the real practical cost of operating these installations of illumination.

CALCULATING AND MEASURING STREET ILLUMINATION

By F. Uppenborn.

From *Zeitschrift für Beleuchtungswesen,* November 30, 1906.

In No. 38 of the *Journal für Gasbeleuchtungswesen,* Dr. Hugo Krüss has shown that not only the photometric measurements of the actual illumination of a street are of interest but their theoretical calculation as well. According to my view, entirely too much weight is laid upon both, especially in the case of gas illumination. In the following let me explain my view of the matter.

Prof. Dreschmidt and Dr. Krüss maintain that the proper basis for calculating street illumination is the intensity on a surface perpendicular to the street. This view I cannot entirely endorse. In 1880 I published formulas for street illumination, in which I set forth the principles of illumination on a horizontal plane as well as of pavement illumination. I do not agree with the contention that the greatest need in street illumination is found in the case of a search for a lost coin. Krüss on the contrary holds that in passing to and fro only the side of the approaching person or vehicle turned toward the observer is to be considered.

I cannot take this view, for vehicles must be lighted at night according to official orders, and people are easily perceived by very defective illumination. According to Krüss, street illumination by horizontal radiation would be entirely satisfactory. But it is really the most unsatisfactory, for interior, as for street illumination. By far the most favorable illumination is obtained from light falling obliquely. If Krüss's views were right, any given street could be illuminated with a search light; but it is a well-known fact that such a method of lighting would be entirely useless.

According to Krüss & Dreschmidt's view, streets lighted with low gas lamps would be illuminated just as well as with arc lamps erected at a great height. Actual observation shows that the streets illuminated with arc lamps of equal intensity are much better lighted than with gas lamps placed low. It is to be further observed, that increased illumination at a given point in a street by a larger number of light-sources is possible only when the vertical components of illumination, as well as the pavement illumination, are taken

into consideration. The equation of normal illumination is:

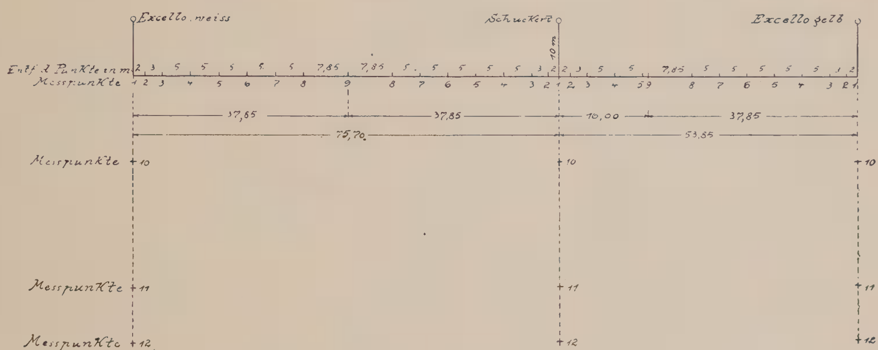
$$E_n = \frac{I}{b^2} = \frac{I}{b^2 \times 2^2}$$

In which I indicated the intensity of the lamp, 1 the distance from the lamp to the illuminated test surface, h the height of lamps above the pavement, and r the distance of the point directly below the lamp on the illuminated test surface. The following equations give the illumination at a given point on the pavement.

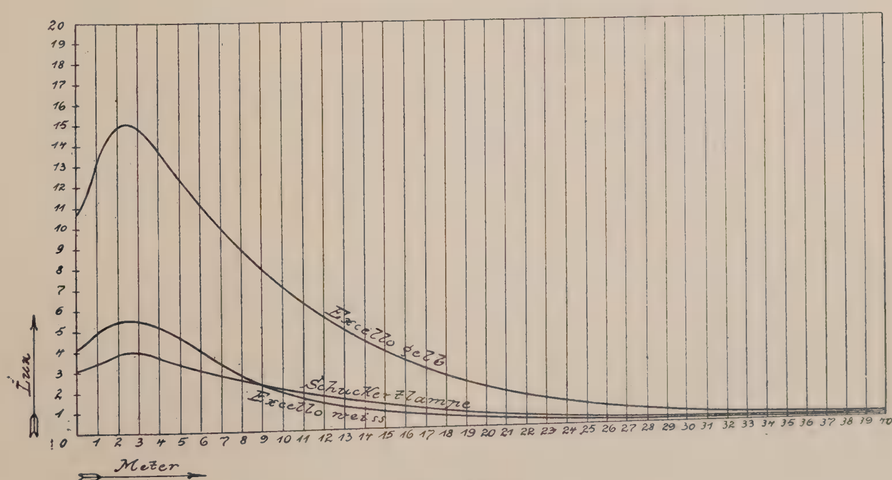
$$E_b = E_n \cdot \cos a = \frac{I \sin B}{h^2 + r^2} = \frac{I \cos^2 B \,.\, \sin B}{r^2}$$

$$= \frac{I \,.\, \cos^3 a}{h^2} = \frac{(h^2 + r^2)}{I \,.\, h}{}^{3/2}$$

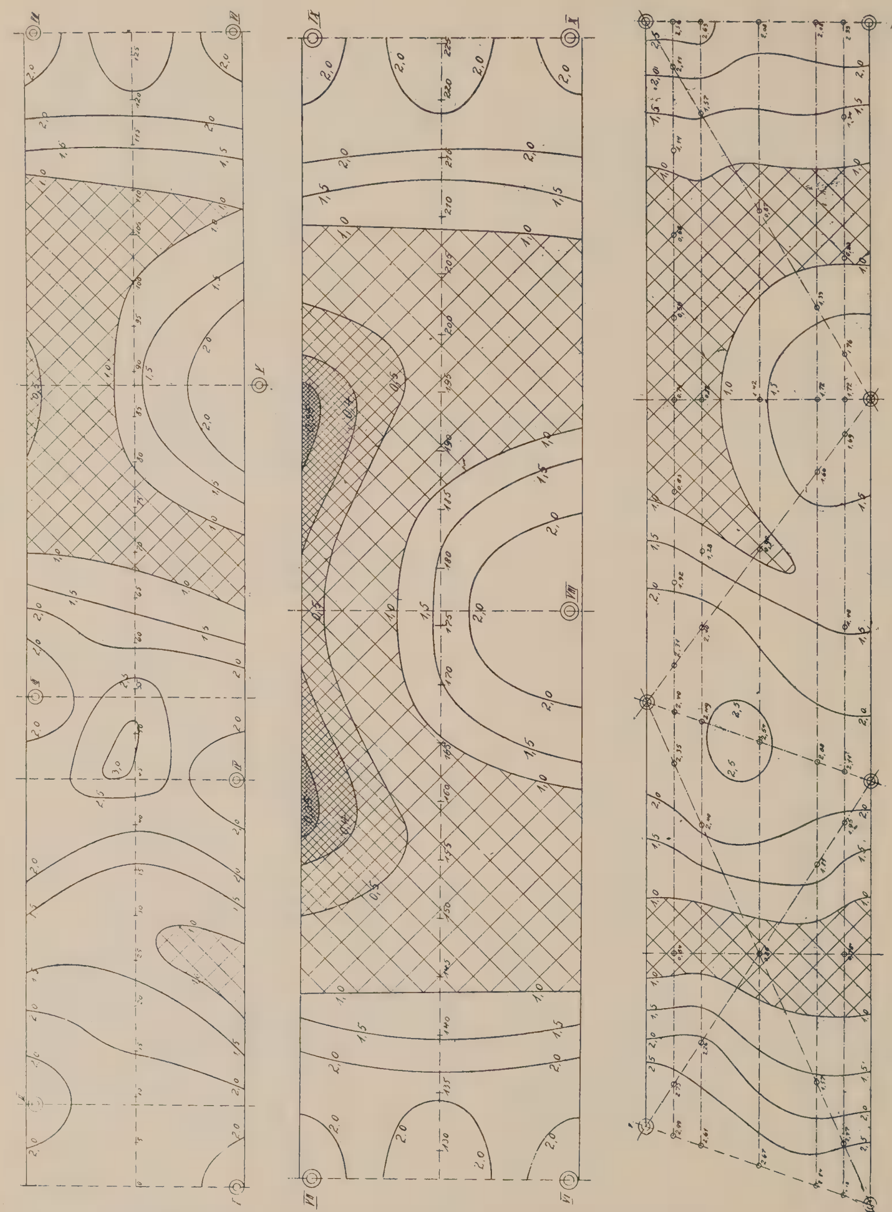
It is evident from this that the normal illumination for cos a = 1 or a = 0, coincides with the pavement illumination. In all other cases the normal illumination has a much greater value. It is plain from the formulas which I have given that the height of lamps is an important consideration, and my original investigations were directed toward determining the best height for the lighting of a given area, under the assumption that the intensity was equal at all angles. It will be understood from this that in 1880 the distribution of the arc lamp at different angles was not known. Dr. Krüss, in his work referred to above, has worked on this assumption, and on this basis has calculated the normal illumination for various arrangement of lamps. In practise, it will be hardly possible to accomplish anything with these estimates, for this assumption does not hold good with lamps intended for street



	Stromstärke	Spannung
Excellolampe, gelb	8,11	45,0
" weiss	8,42	45,0
Schuckertlampe	8,50	42,9



FIGS. 1 AND 2.

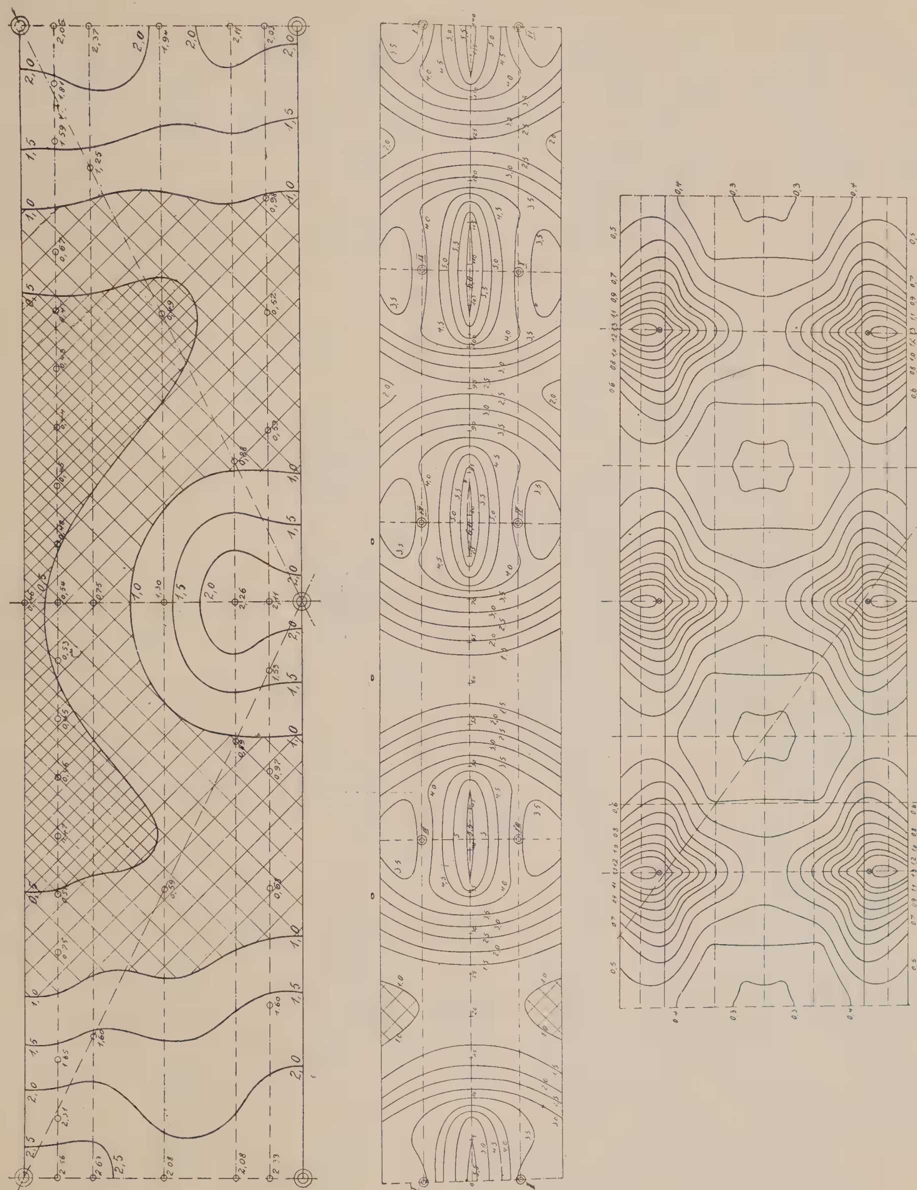


FIGS. 3 AND 4.

illumination, and therefore another method will be taken than the one described by Dr. Krüss.

For many years the following method for the more important illumination has been used at my suggestion in Munich. First of all the curve of illumination on the pavements is determined for the light-sources in question, most of which are arc lamps of 9-10 amp. This can be done in the well-known way from a polar diagram, but is also to be obtained by direct observation. As an example of such observation, a Siemens-Schuckert Co. lamp and a Korting & Mathiessen Excello-lamp may be taken, with white and yellow carbons. In Fig. 1 the outline of arrangement is given. The illuminating values on page 998 result at the locations indicated in Fig. 1.

From these values the curves shown in Fig. 2 are obtained. In estimating the intensity the illumination at a given point



FIGS. 5 AND 6, 7 AND 8

on the pavement resulting from all the lamps under considerations is summed up. The same was done for the illumination of Maximilian's Bridge.

In order to carefully consider the distribution of illumination, curves may be constructed giving the points of equal illumination on the pavement. The "Isolux" curves thus constructed for the Maximilian Bridge are shown in Figs. 3 and 4.

In the calculations, four different plans were laid, the curves in Figs. 3 and 4 applying to plan 4. In reality, this plan was somewhat altered when it was executed. The arc lamps, whose position and number are shown in plan 4 (indicated by double circles) are normally placed at a height of 11.46 m (instead of 10 m, as originally provided in plan 4). The actual illumination obtained was measured by Marten's Illuminometer. The locations at which the illumination was measured, are indicated

by circles, and the illumination found at each point is noted. The illumination is shown on the curves connecting the locations measured. From these curves a plan was made of the locations in which the illumination was 1.0, 1.5, and 2.5 Lux. By connecting the points of equal intensity, the Isolux curves shown in Figs. 5 and 6 result. In Fig. 7 the illumination of the Reichenbach Bridge is shown. The Isolux curves are constructed in a similar manner. Finally in Fig. 8 is shown the illumination of the Cornelius Bridge with gas lighting, from photometrical measurements.

In general, the construction of the Isolux curves consumes entirely too much time, so that the following curve, the use of which has been recently proposed by Dr. Bloch, must suffice: The whole illuminated plane of the street is divided into a nuber of equal squares, and the illumination measured in the middle of these squares. It is evident that in a symmetrical arrangement of lamps it is unnecessary to measure each single square, and that comparatively few measurements are sufficient in a great many cases. In this manner the illumination of the Cornelius Bridge was determined.

When it is a question of the comparative cost of the various methods of illumination, then the mean pavement illumination plays a large part. It is simply the mean value from the illumination of single squares.

	Schuckert Lamps Light effect	Excello lamp, white light effect.	Excello lamp, yellow light effect
1.......	3.06	4.1	10.65
2.......	3.83	5.49	14.9
3.......	3.24	4.66	12.45
4.......	2.09	1.87	7.04
5	1.2	0.85	3.99
6.......	0.62	0.52	1.87
7.......	0.325	0.23	0.98
8.......	0.24	0.18	0.55
9.......	0.145	0.088	0.24
10.......	2.268	6.09	14.25
11.......	2.052	2.31	8.54
12.......	1.207	1.63	4.57

INCANDESCENT MANTLES MADE FROM ARTIFICIAL SILK

THE NEW CEROFIRM MANTLE

By Dr. C. Richard Böhm, of Berlin.

From the *Journal of Gas Lighting*, London, Dec. 25, 1906.

The textile basis of the incandescent mantle originally consisted of cotton yarn of fine quality. In recent years, however, the cottom has been largely replaced by ramie—a material which is far superior for the purpose. Whereas a mantle derived from cotton, after being a short time in the flame, gradually lost its shape, and on that account diminished in illuminating power, the ramie mantle preserves its shape much longer, and the diminution in candle-power after a long period of burning is hardly noticeable. The great drawback to the incandescent mantle, however—its tendency to break—still remained; and the efforts which have been made in recent years have been mainly directed towards improving the stability of it.

Attempts have been made to employ other vegetable fibres—such as silk, hemp, and jute—as the oxide-bearer, with, however, negative results. In the latest researches, the vegetable fibres have been replaced by artificial threads; and the addition of the Welsbach salts is made during the preparation of the artificial silk itself.

It is now common knowledge that Chardounet succeeded in preparing threads and cloth, which had previously only been produced from organized fibres of vegetable and animal origin. He employed cellulose in the form of a solution of collodion or gun cotton. This artificial or cellulose silk is made by the following process: The nitro-cellulose, prepared by the action of a mixture of sulphuric and nitric acids on cotton wool, is dissolved in a mixture of alcohol and ether in equal proportions, until a thick fluid is formed. The solution is filtered; and from a tinned steel vessel it is pressed out through fine glass tubes of 0.08 mm. diameter under a pressure of 50 atmospheres. The threads congeal immediately on coming into the air. No treatment with water is necessary; since the volatile vapors are taken away by means of suction plant. Several of the fibres are immediately spun to obtain a thicker thread; and the material is denitrated by means of ammonium sulphide. The explosive properties are thus removed, and a substance consisting essentially of cellulose again remains.

I say "essentially," because the cellulose by this process is altered chemically, and its characteristic properties are changed. By the application of an ammoniacal solution of cupric oxide (Schweitzer's reagent), solutions of cellulose have been obtained, which have been put to certain technical uses. This application is limited, because for most purposes either the solvent is too costly or the presence of copper in the solution is inadmissable. By the action of an ammoniacal cupric oxide solution, the copper compound of cellulose is formed; and after drying the substance the copper can be removed by acetic acid.

Cross, Bevan, and Beadle have also found a new process by means of which the cellulose is dissolved and reprecipitated without any essential chemical alteration. This process is cheap, and yields a product which can be put to a variety of uses.

The starting material of the new process is the well-known substance produced by the action of caustic alkalies on cellulose. A bulky, transparent mass is formed by the assimilation of alkali and water. It is familiar in the process of mercerization. This substance is then further changed by the action of carbon disulphide—swelling up still more until it becomes completely gelatinized, and is then soluble in water. The aqueous solution has a yellow color, and is very viscous. From this solution the cellulose can be separated with its original properties. While the dissolved cellulose in this process is called "viscose," the separated product is known as "viscoid."

The artificial threads produced by the three methods above described are distinguished from fibres of natural origin, in that they are not tubular but solid throughout; and the cellulose is presented in the hidrated gelatinous form instead of in the form free from water. This fact is of great importance in the subsequent operations of preparing the incandescent mantle. The dissolved cellulose has a plastic form, and readily adapts itself to the treatment adopted.

At one time—when the Auer patent monopoly did not permit the manufacture of mantles on the part of competitors—a patent was taken out by Knöfler in 1894 (German patent No. 88,556) for a process in which suitable proportions of the salts of the rare earths dissolved in alcohol were added to the collodion solution. The threads pressed out through capillary tubes were either dried in hot air or pressed under water.

The burning off of such threads, or the tissue woven from them, takes place very violently, on account of the unchanged nitrocellulose. On this account it is necessary to denitrate the tissue by means of ammonium sulphide. By this treatment, the explosible nitro group is removed, and the rare earths are converted into hydrates.

While Knöfler made use of the salts of the rare earths containing water of crystallization, Plaissetty took as a binding material the anhydrous salts (German patent No. 129,013) with the addition of the least trace on collodion. The product which is obtained by this process, after drying, is said to burn off slowly, and can be used without any previous denitration. In order to make the tissue more flexible, it is treated with ammonia, whereby the hydrates are formed. In this way, Plaissetty arrived at the same product as Knöfler.

According to an English patent (No. 26,381, of 1897) of Blasco de Léry, the salts are dissolved in acetic acid, and, after the addition of glacial acetic acid, mixed with a solution of collodion wool, 3 to 5 parts, and 120 parts of acetic acid, a mass is obtained which can be spun. The mantle made from the spun threads weighs, before burning off, about 5 grammes, and yields 0.6 gramme of ash. By Plaissetty's process as mentioned above (German patent No. 129,013), a material which can be spun is obtained by the mixture of 9 parts of collodion wool, 15 parts of salts, and 31 parts of solvent. The mantle knitted from such threads also yields 0.6 gramme of ash; but, on the other hand, it only weighs 1.5 to 1.6 gramme. So that it is considerably lighter in weight than that produced by the English process.

Plaissetty maintains that all these methods are associated with great drawbacks, since the viscose from which the artificial threads are otbained can only take a limited amount of the earths, and the resulting threads are difficult to spin.

In 1893, Schlumberger and Tinibaldi, in a Belgian patent (No. 106,592), indicated the possibility of impregnating threads of artificial silk with the thorium salts. Plaissetty, too, has shown that these artificial threads—in spite of the fact that they lack the hollow interior of the natural fibres—can nevertheless be impregnated with the salts to produce a serviceable mantle. According to the process patented in 1902 (German patent No. 141,244), the artificial silk is dipped into the solution of salts; and, on account of its collodial nature, practically any amount of nitrate can be absorbed. In this respect, artificial silk differs from cotton, which will only absorb a limited quantity.

In the new mantles, a direct combination takes place between the cellulose and the salts, which is supported by experiments with the microscope. The silk, after being impregnated with the nitrates of the earths, is carefully dried, and then immersed in a concentrated solution of ammonia. The nitrates are thereby converted into hydrates, which enter into inti-

mate combination with the gelatinous cellulose. Although the thread contains about 40 per cent. of its own weight of nitrate, it does not appear changed in any way. It possesses the same bright appearance, and has about the same bulk as before.

This process has now been worked out sufficiently to allow of its being exploited commercially. The French patent was acquired by the French Auer Company, while the German patent was bought by the Cerofirm Gesellschaft (formerly Bruno and Lietz), of Berlin.

By literally following the Praissetty process for producing incandescent mantles from collodion silk, a good result is obtained, but showing no particular advantages over the ramie mantle. In the first place, the stability of such mantles leaves much to be desired. Now this is the most sensitive spot of the incandescent gaslight industry; and for a long time experimenters have endeavored to produce a mantle which will not break. Until recently, none of the many investigations directed towards this object has been successful. It is true that the stability of the mantle can be increased to a certain degree, by impregnating it in the solution to a greater extent; but the increase in stability is so small that it has practically no value. The illuminating power of such mantles is moreover considerably smaller than that of the ordinary mantles. It has also been attempted to produce incandescent mantles from fine wires, or incombustible threads—such as asbestos. This, too, seems to be the nearest way of approaching the problem of the stable mantle. But the results have always been negative; and it is only to be expected, because the mantle, on account of its greater bulk and weight, absorbs too much heat from the flame, and on that account emits relatively less light.

Plaissetty, however, was on the right way of solving the problem of the stable incandescent mantle. The well-known experimenter, Bruno, acknowledged that thorium hydrate possesses so many excellent properties that for the manufacture of incandescent mantles it is far superior to thorium nitrate. Thorium nitrate is known to possess a property by virtue of which, on heating, it blows out and expands considerably. This behavior of thorium nitrate is used as a test, since it is supposed that a sample which exhibits a propensity to expand yields an incandescent mantle which does not conglobate (wrinkle). The conglobation or wrinkling is a phenomenon which shows itself in the early stages of the burning of the mantle, and it is undesirable, since it is also associated with a rapid decrease of illuminating power.

The thoria derived from thorium nitrate forms a loose powder, which can be rubbed down on the surface of the palm something like meal. On the other hand, the thoria derived from thorium hydrate by heating to incandescence does not display this phenomenon of expansion, but conglobates immediately—yielding, instead of a loose powder, sharp oxide crystals of diamantine hardness.

These apparently defective properties of thorium oxide derived from the hydrate appeared to make it entirely unsuitable for the manufacture of incandescent mantles. But even if the mantles produced from collodion silk by Plaissetty's process show no particular superior advantages nevertheless their relations are altogether changed when we pass over to another artificial silk. As already described, cellulose with unchanged properties can only be separated from an ammoniacal cupric oxide solution. If now the cupric oxide cellulose fabric is treated according to Plaissetty's process, a mantle is obtained possessing quite unexpectedly valuable properties.

The former unburnt mantles had the undesirable property of withdrawing moisture from the air with great avidity. Since almost all gas-works and many large contractors take their mantles not in the burnt-off, transportable state, but as half manufactured—i.e., unburnt-off—so this hygroscopic property of the mantle is a source of unceasing trouble. The mantles becoming moist contract when subsequently burnt off, and easily become irregular and crooked. The new mantle—from copper cellulose by the Plaissetty process—is, however, not hygroscopic; since the thorium hydrate, unlike thorium nitrate, does not absorb the least trace of humidity. It will, therefore, be seen that this property may be an exceedingly valuable one.

For the testing of mantles with a view to stability, mechanical vibratory machines have been constructed, which transmit vibrations in both the vertical and the horizontal directions. On a Drehschmidt machine adapted for intense vibrations, some comparative experiments have been performed. An ordinary mantle of good quality withstood 90 to 100 vibrations. The new mantle, however, remained perfectly intact after 3,000 vibrations. There can be no doubt, therefore, that this mantle is far more stable than the ordinary one. The mantle was exhibited by Bruno in a lecture delivered in Nuremberg in June this year. The mantle can be taken in the hand, after burning off the protective film of collodion, and put to various tests. It may, for instance, be rolled on a pencil without breaking. It not only possesses greater tensile strength than an ordinary mantle, but is also much more elastic. These excellent features denote the great advance which has been made by means of this discovery.

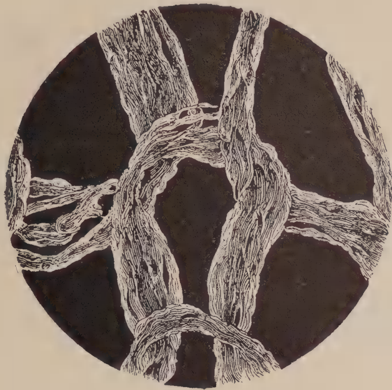


FIG. 1.

The accompanying illustrations serve to demonstrate the microscopic structure of the old and new mantles. Fig. 1 shows a loosely interwoven thread of a ramie mantle, consisting of a countless number of entangled fibres. Fig. 2 shows a similar portion of an artificial silk mantle. It will be observed that the threads are not entangled as in the ramie mantle, but stand out distinctly, more like wires. The quantity of individual fibres is also much less in the case of the new mantle. The illustration serves to distinguish clearly the great structural difference between the vegetable fibre and the artificial fibre.

On account of the great importance of the new invention, it was supposed that the competitors would test the validity of the patent. The proprietors of the German patent, the Cerofirm Gesellschaft, therefore, conducted very careful investigations before coming before the public with their new mantle.

The patent claim of Plaissetty's ammonia process runs as follows: "Process for the preparation of threads for incandescent mantles consisting in impregnating artificial threads of all kinds, or tissues from such threads, and after drying leading through an alkaline bath and then drying again."

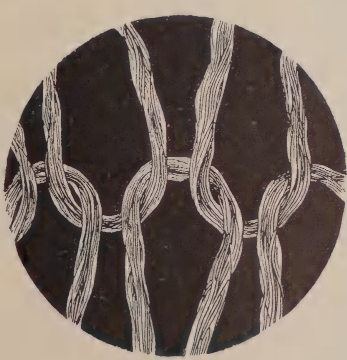


FIG. 2.

Since the alkaline bath is the most important feature, investigations were made to see if the formation of hydrate could not be brought about by means of other reagents. Now this question was easy to answer for a specialist in the rare earths, since an analytical process is known by which the thoria is precipitated by means of hydrogen peroxide. The use of hydrogen peroxide in the manufacture of mantles was also not new, having been proposed by Drossbach as far back as 1899 (German patent No. 117,715). Drossbach found that the higher oxidized salts of thorium—especially the nitrate—after the usual addition of ceria, were especially suitable for the manufacture of incandescent mantles. After bringing the same to incandescence, the thoria remains behind in a peculiar molecular condition, the illuminating power of which—the same consumption of gas and other things being equal—is far higher than that of the ordinary mantle. For instance, the photometrical determination gave 143 Hefner candles as against 80 Hefner candles with a mantle from normal thoria and ceria.

The peculiar character of the higher oxide of thorium consists in the greatest illuminating power being evolved with an addition of 1.6 per cent. of ceria, and in the fact that the light emitted is snow-white. On the other hand, a normal mantle with an addition of only 1 per cent. of ceria gives out a yellowish green light; while with 1.6 per cent. of ceria a dull reddish yellow light is emitted. Also, under the microscope, the mantle prepared according to Drossbach's process appears considerably altered. The fabric of an ordinary thoria-ceria mantle under the microscope seems quite uninjured, and only in a few places is the yarn rolled open, due to the expansion of the thorium nitrate, as previously mentioned. By the use of the higher oxidized nitrates, the thread is resolved into its individual fibres, by virtue of which the exterior surface is enlarged and the illuminating power increased. The Drossbach process for the production of incandescent mantles differs from the old process in that—in place of the salts of thorium previously used—the higher oxidized compounds are employed. The impregnation, drying, and burning off operations are carried out in the usual way. The patent claim states as follows: "Process for the production of incandescent mantles consisting in employing the higher oxidized salts of thorium, obtained by the oxidation of thorium solutions, in place of the previous employed normal salts."

Since hydrogen peroxide solutions react slightly acidic, it was easily possible to evade the Plaissetty patent by substituting hydrogen peroxide for the alkaline bath. As also the researches in this connection

had proved that the mantles produced by means of hydrogen peroxide were superior to those produced by the use of ammonia, a patent was applied for; and then, for the first time, the new mantle was made public.

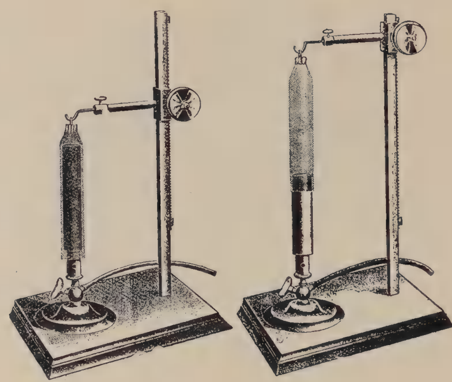
The application for the patent was filed on March 6 last, in the name of Albrecht, and was open for inspection on July 23. Unlike the invention of Drossbach, by treating the impregnated mantles with hydrogen peroxide, a thorium hydrate is obtained which does not expand but coheres; and owing to this property great stability is conferred on the mantle. The patent claim states: "Process for the production of incandescent mantles by the use of hydrogen peroxide, consisting in treating the thorium salts of the impregnated unburnt-off mantle with hydrogen peroxide."

Since hydrogen peroxide only converts the thoria into an insoluble form, sufficient cerium nitrate is added to the solution to produce the desired proportion of ceria which the mantle shall contain. This is readily controlled by empirical means.

The mantle prepared by the modified Plaissetty hydrogen-peroxide method does not, according to Bruno, contain the thorium as the ordinary oxide (ThO_2), but as a higher oxide for which the formula Th_2O_7 has been assumed. Judging from previous scientific investigations, thorium peroxide does not resist heat; but, nevertheless, Bruno attributes the remarkable physical properties of the mantles produced by the modified Plaissetty hydrogen peroxide process to a higher oxide of thorium, since the new mantles often emit a light of 130 to 140 Hefner candles. The average is 120 to 130 candles with the ordinary gas pressure and consumption.

But I have already shown that the mantles made by Drossbach's method also emit a light of 140 candles. Drossbach has attribtued this phenomenon to the enlargement of the exterior surface, while Bruno inculcates that with his process a thorium hydrate is produced which does not expand or blow out at all. The principal feature attained by Bruno's patent seems to me not to consist in its high, light power, but in the remarkable stability of the mantle. It is true that the patent specification lays more stress on the great emission of light produced by the new mantle. But it seems to me the relations are reversed, and that the hitherto unattained stability exhibited by the new mantle is its most striking feature. Latterly Bruno appears to have altered his view; and he now considers the stability and elasticity of the new mantle to be its most valuable characteristics.

Up to the present, it has only been possible to manufacture incandescent mantles from artificial silk by the aid of special apparatus and methods. In particular, it has



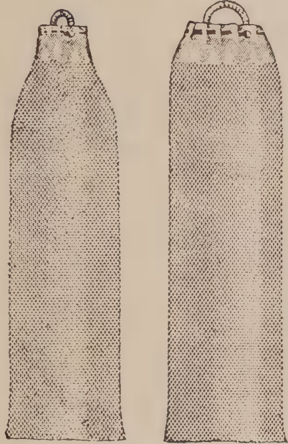
FIGS. 3 AND 4.

not been possible after the impregnation of these mantles to convert them into ash, mold and harden them by the use of the blow-pipe. When collodion mantles are turned into ash, as soon as the salts in the heat of incandescence are converted into oxides, the artificial threads do not retain their uniformly extended form, as do the natural ones from ramie and cotton. They curl up together, so that subsequent treatment with intensified gas for molding and hardening is impossible.

To overcome this curling, the mantles are ashed, molded, and hardened in one operation. The mantle is supported over a burner tube corresponding to its width, so that only the top of the mantle projects above the head of the burner, as shown in Fig. 3. The intensified gas is now allowed to enter, and is ignited. The mantle is then raised slowly through the flame—about 1-50th of an inch at a time. Having once been drawn through the flame, the burning off is complete—Fig. 4. The pressure of the intensified gas should in no case be higher than about 8 inches, which is much less than that used in the manufacture of ramie and cotton mantles. When the flame roars, it is quite sufficient, as too high a pressure is injurious. The mantle after burning off should not be hard, like a ramie or cotton mantle, since it is really toughest, or, better expressed, more elastic, when in the soft state. It is better that the mantle should be somewhat pointed, as shown in Fig. 5, and not full like the ordinary variety—Fig. 6. It has been found that the pointed form not only gives the best illuminating effect and the most economy, but also lasts the longest.

The process for burning off the mantle has also been patented in the name of Albrecht (for the Cerofirm Gesellschaft), on March 6 last, and was declared open for inspection by the German Patent Office on July 23.

There can be little doubt that this last



FIGS. 5 AND 6.

great step forward has been due to the united efforts of Plaissetty and Bruno. Like most inventions of great general importance, the new process is the result of the labors of many patient workers. It must not be supposed that the idea of an invention is always the most important point. On the contrary, the working out of the same generally presents the greatest difficulty; and for this reason it should not be esteemed less highly. So it is in this case. It was known that artificial silk might be impregnated with the salts of the rare earths; it was known that the threads of cupro-cellulose were suitable for this purpose; and the action of hydrogen peroxide on the rare earths was also well known. All these, however, did not suffice to produce a mantle superior in stability or elasticity to previous ones. A very important factor was still missing, and that was the right comprehension with which the various inventions must be considered before any real practical success could be attained.

Finally, it is well to point out that in the new mantle some secret process seems to be involved. By literally following the process set out in the patent specifications, negative results only are obtained. When the ramie mantle was first introduced, it was a long time before the proper treatment and working up of this fibre was thoroughly understood. Not till then did ramie yield an incandescent mantle far surpassing in its qualities the older cotton mantle. It may safely be assumed, therefore, that the same relations hold in the case of artificial silk. Cupro-cellulose has its peculiarities; and these must be understood before the many difficulties can be overcome. The Vereinigten Glauzstoff-Fabriken, of Elberfeld, are delivering the woven fabric to the Cerofirm Gesellschaft, and are also participating in the venture. There is thus every reason to suppose that competitors will have great difficulty in obtaining supplies of the necessary raw material. The first-named Company have been manufacturing artificial silk for some time, and are reported to be making huge profits, like most of the other Continental concerns manufacturing artificial silk. Bruno probably regards his business relations with the Vereinigten Glauzstoff-Fabriken quite as important as the purchase of the Plaissetty patent.

The incandescent gaslight industry may, I consider, heartily congratulate itself. It has scored another immense success—being now capable of producing a mantle in which the one great drawback of fragility is forever set aside.

AUTOMATIC LIGHTERS FOR STREET GAS LAMPS

In his last report, Albert Halstead, United States consul at Birmingham, England, states that an automatic gas controller has been patented and is now on sale in England, which, if in practical operation fulfills the claims made by its owners might materially lessen the cost of public lighting in the municipalities of the the United States. The controller is said to be adapted to any type of incandescent burner, to fit any lamp, and to be instantaneous in its lighting and extinguishing. The mechanism consists of a clock which can be so set as to light the gas each night and extinguish it each morning, so as to make an automatic variation of the time of lighting and extinguishing according to the calendar. In other words, by means a chart, the street lights are turned on and off, lighted and extinguished, at a different moment each day throughout the year, according to the season. This, it is claimed, is an advantage over any controller now on the market, one adjustment a year being sufficient. They require no attention except winding once a week or a fortnight, and when once set do not have to be reset throughout the year. The gas can be turned off and on in the ordinary way, quite independent of the gas controller. This is important, as it might be neccessary to turn off the gas for the renewel of the incandescent mantles.

These controllers are now on trial at Bath, and the engineer of the gas company there has informed the municipal gas department at Birmingham that so far as their experience goes it gives satisfactory results. The city of Birmingham proper has 13,860 street lights, and the district outside, which is supplied by the municipal gas department of Birmingham, has 7,108 street lights. Their caretaking costs $102,-484 per annum. To equip these street lights with this gas controller would involve an expenditure of $153,061.

Miscellaneous News

Easton, Pa.—Disgusted by the poor service given by the municipal street lighting plant, sixty leading men and business firms of Easton have petitioned Select Council to advertise for bids for running the plant until a private corporation can take it over. The service is so poor that women and children are not considered safe on the streets at night. The municipal plant has been run at a loss of from $4,000 to $5,000 a year.

Albany, N. Y.—The recommendation of Governor Hughes that the State Commission of Gas and Electricity be abolished is of great interest to members of the Empire State Gas and Electric Association, which declared for the appointment of the present lighting commission and as a matter of general policy has upheld the commission throughout its official life.

The association was formed two years ago, when public curiosity and interest in the lighting question were at fever heat. It was then that a few of the lighting men of the upstate region got together. They were ready to treat with the public through men who knew a kilowatt from a candlestick, they declared, but not through every self-appointed lighting expert who chose to climb the hill at Albany and make a speech before the nearest committee. Since then there have been searching investigations and reductions that hurt; but to the minds of the upstate lighting men a judicial hearing, with a threshing out of the question fairly to both sides, was infinitely preferable to coping with committees and councils where "loose talk" was bandied about by the layman.

That the majority of the lighting men of the state have gradually come to their way of thinking has been proved by the increase in the membership of the association, which now numbers more than fifty of the upstate lighting companies. To further rather than to fight the properly constituted state authorities is the principle for which the association stands.

Schenectady, N. Y.—At a meeting of the board of directors of the Business Men's association and the lighting committee of the association the question of the new schedule of rates as prepared by the Schenectady Illuminating company was discussed and it was decided that they were not satisfactory and will be referred to Frank C. Perkins, an expert consulting electrical engineer of Buffalo, who gave an opinion in the matter some time ago. When Mr. Perkins' report is received, the question of rates will again be taken up with the officials of the Illuminating company by the Business Men's association.

Montreal, Canada.—The question of candle-power as a standard for illumination and heat, which was brought up yesterday by Ald. L. A. Lapointe's discovery that the gas proposal now before Council reduced the candle-power from 21 to 16, was called to the attention of Mr. W. McLea Walbank last evening.

Mr. Walbank admitted without hesitation that Ald. Lapointe's contention as to the fact was correct, but he was inclined to belittle the importance attached to it.

"This town," said Mr. Walbank "is asking higher candle-power than any other. The 16 candle-power is the standard in England and in the Dominion of Canada, that having been found to best reconcile the twin users of lighting and heating. Gas for lighting is not much used now with an ordinary burner, but is used with a mantle. Gas has to be enriched to give high candle-power for illuminating, but with the mantle the 16 candle-power is sufficient and you get much better heat.

"Of course people will not be satisfied if they do not get the light but with the mantle that point is solved, while at the same time you do not have to get it so high as to sacrifice the heating qualities which has to be done now. The 16 candle-power as I say, is the standard which expert experience has fixed and which has been adopted by Dominion statute."

The Palms, Cal.—There is great activity at The Palms in all directions. Arrangements have been completed to erect an electric light plant, and the public subscription for lighting purposes has already reached a sum sufficient to light the city for six months.

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Practical Problems in Illuminating Engineering

THE LIGHTING OF A LARGE DEPARTMENT STORE

BY F. M. FEIKER.

SECTION OF FIRST FLOOR, MYERS' STORE, ALBANY, N. Y.

It is not long since the 16-candle-power incadescent lamp was the unit of store illumination for electric lighting from the basement trunk-room to the offices on the top floor. While this method of displaying goods at night was much better than gas lighting, the advantages of the arc lamp as a means of indoor illumination could not be realized, owing to the inherent disadvantages of the open type arc light for interior work.

With the advent of the enclosed arc

PART OF FIRST FLOOR.

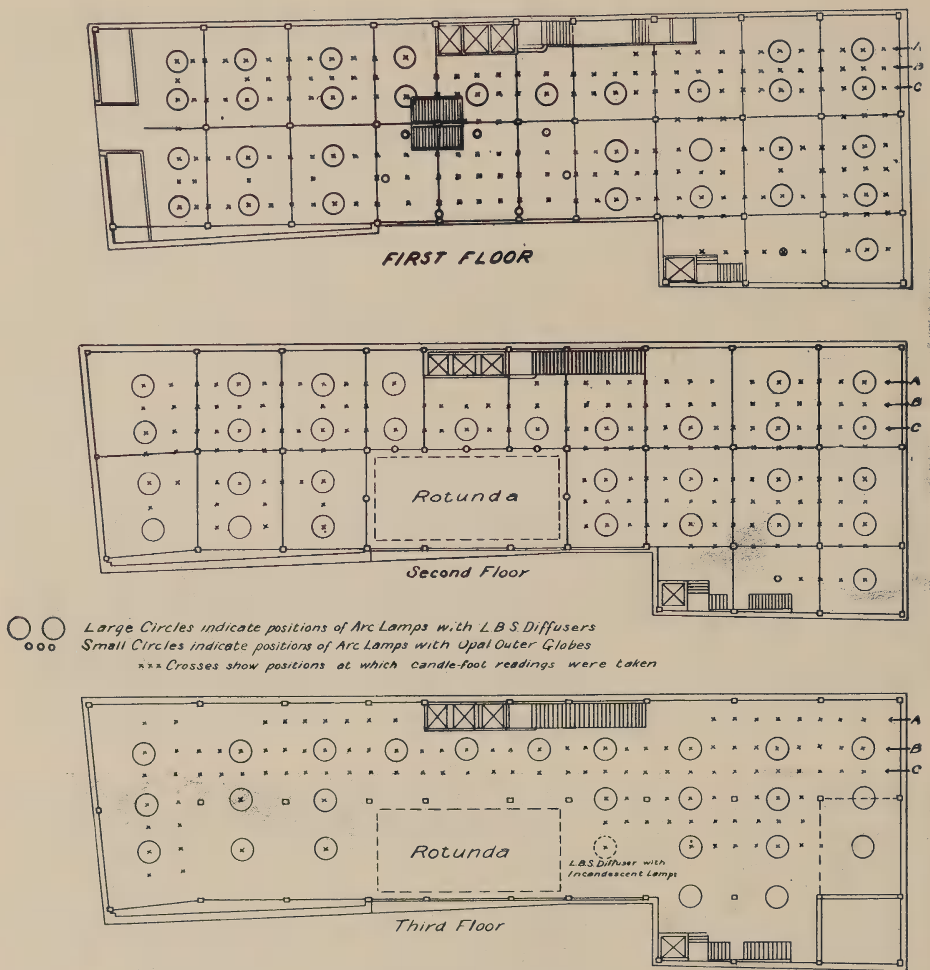
lamp, however, with suitable reflectors and diffusers there has come a widespread adoption of this type of lamp for store lighting. While the auctioneer in a Japanese curio shop may tempt prospective purchasers by holding the delicately figured china before an incandescent lamp, the display of such merchandise is more effectively made in contrasted groups and on a large scale by means of powerful enclosed arc lamps, giving an even distribution of brilliant light over the stock. The incandescent unit, especially in the new "high-efficiency" types, is still adapted for lighting restricted areas, such as basement trunk-rooms, but for brilliant and diffusive lighting the enclosed arc lamp has come to be pretty generally recognized as standard.

Perhaps no better example of the use of enclosed arc lamps in modern store lighting can be found than that exhibited in the John G. Myers store at Albany, N. Y. Being a department store, the lighting includes many conditions found in a variety of establishments, all of which are correlated, and met advantageously by the use of enclosed arc lamps with light balancing selective diffuser ceilings. The daylight effects which are obtained in this establishment by this means, bring out with marked effect the richness of the appointments and the attractiveness of the merchandise. Dress goods and fabrics of all kinds show nearly exact color values in the light of the arc lamp and the brilliancy of cut glass and detail of many notions are emphasized by the same pervasive illumination. No better exponent of the artistic results of the illumination could be found than the illustrations from night photographs which accompany the article.

Ceiling lamps were decided upon after a series of tests had been made, the lamps being arranged as shown in

FIRST FLOOR, REAR.

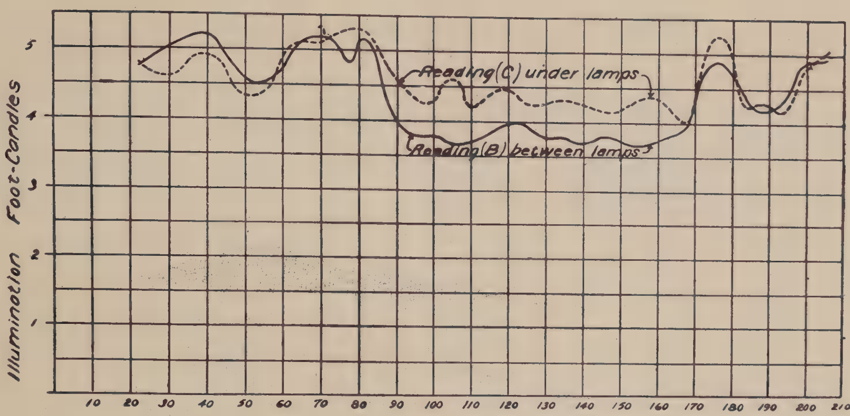
SECOND FLOOR.



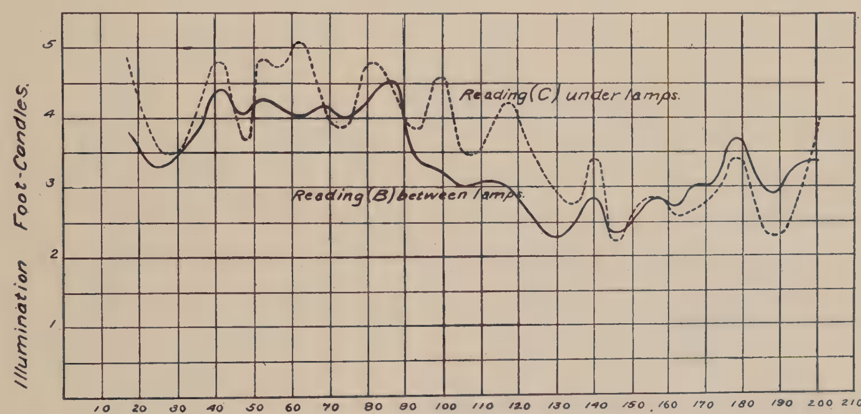
FLOOR PLANS, MYERS STORE.

the accompanying diagrams. An outer ring of plaster is provided around each of the lamps, with its reflector so that the lamp in its setting harmonizes with the rest of the ceiling. In addition to the ceiling type of arc lamps, a small number of ordinary double globe type lamps are suspended around the rotunda in order to supplement the illumination about the openings in the ceilings where the ceiling type of lamp could not be installed. As the ceilings of the basement are too low to install the ceiling type of lamp, the ordinary enclosed arc lamps are used there.

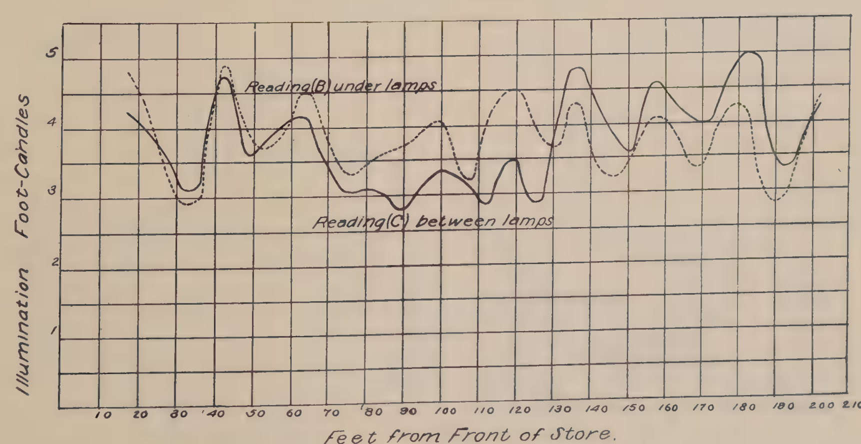
All the arc lamps are controlled from panel boxes located in the side walls, with doors matching the prevailing mahogany finish throughout the store. Current for the lamps as well as for various motors and electric heating devices, is supplied at 118 volts, 38 cycles from the mains of the Albany Illuminating Company. Each lighting unit consists of a General Electric ceiling type, alternating current, multiple, enclosed arc lamp, hung in a light-balancing selective diffuser ceiling reflector. The lamps on the first floor are adjusted to take 8¾ amperes and on the



FIRST FLOOR.

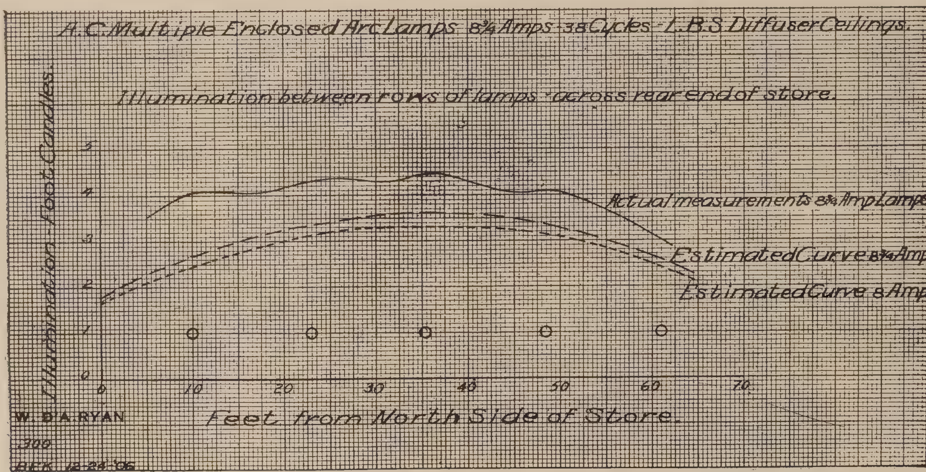


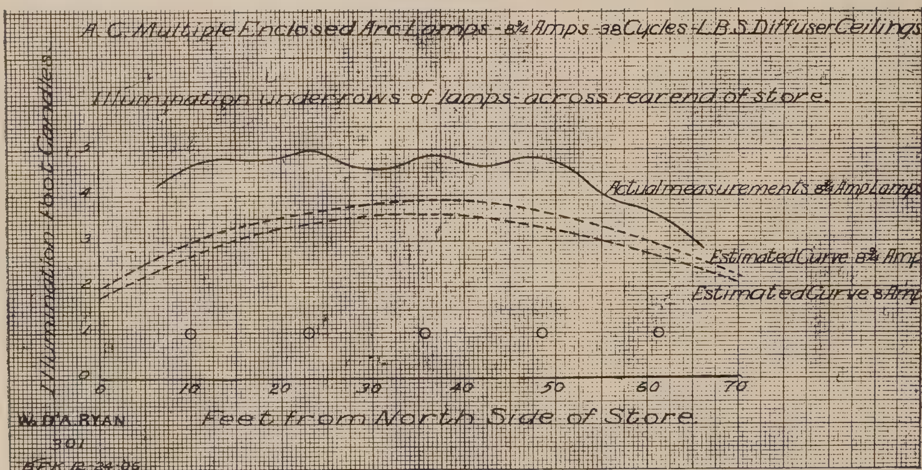
SECOND FLOOR.



THIRD FLOOR.

ILLUMINATION TESTS, MYERS' STORE.





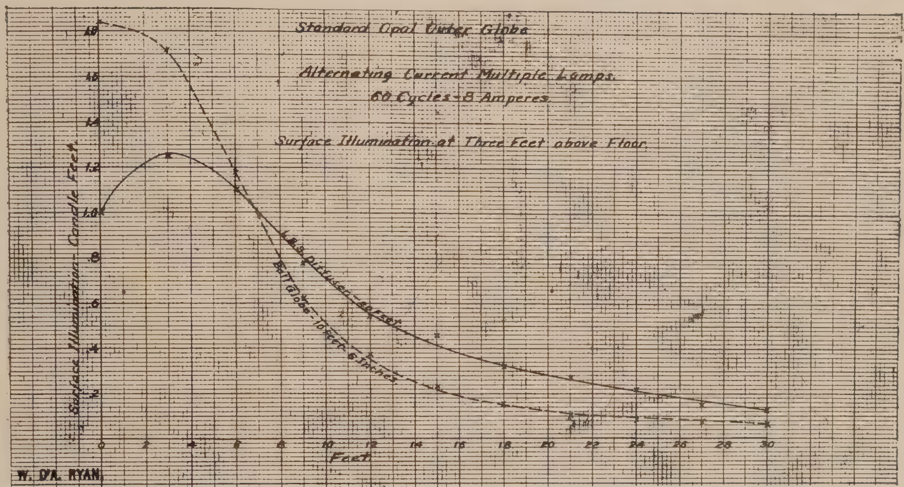
CURVES SHOWING ESTIMATED ILLUMINATION COMPARED WITH ACTUAL MEASUREMENTS, NO ALLOWANCE BEING MADE FOR REFLECTION.

second, third, and fourth floors to take 6¾ amperes.

It is interesting to note that the results in this store were prophesied by the engineers in advance and the whole installation was made the subject of a most careful investigation to determine the most efficient method of lighting. At the instance of Mr. P. R. Moses, of New York, who acted as consulting engineer for the John G. Myers' Company, the illuminating engineering department of the General Electric Company carried out a series of tests to determine the best method of illumination.

To this end, a ceiling type of lamp was suspended with the arc twenty feet from the floor corresponding to the height of the store ceiling from the main floor. The double-globe enclosed lamp was suspended with the arc ten feet six inches from the floor. The intensity of illumination from each of the lamps burning independently was then measured at a height corresponding to the counter level, over a circle having a thirty-foot radius around the lamp as a center.

The results indicated on the accompanying curve sheet No. 1 (209) show considerably in favor of the ceil-



ILLUMINATION FROM SELECTIVE DIFFUSER COMPARED WITH OPAL OUTER GLOBE, A. C. 8 AMP. LAMP.

ing type of lamp, this lamp giving a higher intensity all over the circle with the exception of the part immediately under the lamp. In this space the light from the ceiling type of lamp is ample and the excessive light of the standard lamp detracts, if anything, from the general illumination, making the remainder of the circle look darker by contrast. From these measurements the minimum intensity of light which could be expected under and between rows of lamps across the rear of the store was estimated. This curve also shows that the ceiling type of lamp is preferable since the intensity of light between rows of lamps is much more uniform.

After the lamps had been installed and adjusted measurements were made with the illumination photometer and the results so obtained compared with the estimated distribution of light. Curves No. 2 and No. 3 show the actual measurements with the estimated curve to which reference has been made in the preceding paragraph. That estimated and actual results should check so closely is a striking instance of the value of the new illuminating engineering. In the estimated curve no allowance was made for reflection from ceilings and walls, or for light received from lamps over thirty feet away. The actual measurements exceed the estimated by about thirty-three per cent, and it is reasonable to assume that this amount of light represents that received by reflectors and from distant lamps.

In order that the matter may be conveniently assimilated the data for the first three floors of this installation are shown in the accompanying table. The offices and stock rooms in the fifth and sixth stories of the building respectively, are lighted by clusters of incandescent lamps.

Floors	First	Second	Third
Area Sq. Ft.	11770	10500	10140
Height to Ceiling	18.4	15.2	13.4
No. Ceiling Type Lamps	31	31	25
Total Watts	20000	15500	12500
Watts per sq. ft.	1.70	1.48	1.23
No. Pendant Lamps	8	6	
Total Watts	24000	18500	12860
Watts per sq. ft.	2.02	1.76	1.27
Average Illum. in Ft. candles	4.27	3.79	3.65

Plain Talks on Illuminating Engineering

By E. L. Elliott

VII. THE LOCATIONS OF LIGHT SOURCES: GENERAL CONSIDERATIONS

Before the advent of the electric light the possible positions of light-sources were comparatively very limited. A flame gas burner, which was the most important commercial source, and the only one used in cases where anything like engineering skill might be used in its installation, had to be so placed as to be accessible for lighting; the burners had to have an upright position, and be removed to safe distance from ceilings and walls. All of these limitations are absent in the case of the incandescent electric lamp, with the possible exception of providing that the lamps may be replaced when burned out with a reasonable degree of convenience. This almost unlimited adaptibility of the electric lamp as to location and position is even yet not fully appreciated by those who have heretofore commonly had charge of laying out lighting systems. The traditions of candles and gas flames are still very much in evidence, especially in domestic and other small installations.

In determining the location of light-sources two general plans may be followed:

First, to place them so as to produce as nearly as possible an equal illumination over a given surface, or throughout a given space.

Second, to place them so that particular points or places will receive a specific illumination.

In many cases a combination of both of these general methods will give the best results.

The first case may be classed as general illumination; the second as special illumination.

Among the important cases requiring general illumination may be mentioned assembly rooms of all descriptions, such as churches, theatres, public halls, hotel lobbies, ball rooms, parlors and drawing-rooms; of the latter class, counting rooms and offices of various descriptions, work shops, libraries and reading rooms.

In seeking to produce general illumination, it is natural to try to simulate daylight effects. Note the use of the word "simulate," and bear in mind that it is not possible to even imitate daylight illumination by any artificial means at present available. This fact is due to several causes. A room well illuminated by daylight, receives its light through one or more windows. These windows are so arranged as to admit only diffused sunlight, the windows being provided with translucent curtains, so as to prevent the direct rays from shining into the room. The degree of diffusion of daylight illumination therefore surpasses anything that may be hoped for from artificial illumination.

It will be well here to get a clear idea of what is meant by "diffusion." The term is frequently erroneously used in the sense of distribution, which is quite another matter. The Standard Dictionary says that to diffuse means primarily "to pour or send out so as to spread in all directions." Diffusion, as applied to light, refers to its "spreading in all directions." A perfectly diffused light is one in which rays of equal intensity cross in every direction at every point; and the degree of diffusion therefore may be considered theoretically measured by the extent to which it approaches this condition. Theoretically perfect diffusion, however, is not desirable in any case, whether by natural or artificial light, as the effect of such light is extremely trying to the eyes; a familiar example of which is sun-light diffused through a thin fog, which

perhaps comes the nearest to the theoretically perfect diffusion of any actual case. It is desirable, however, that there should be such a degree of diffusion that every point should receive some light from every direction, with a preponderance of intensity from a single direction. This is the condition which prevails in a room illuminated by daylight received from windows, on one, or two, adjacent sides; a condition which is usually sought in school rooms. If the walls and ceilings of such a room are of fairly light finish so as to give reasonable reflection, every point in the room will receive light from all directions, with a preponderance from the direction of the windows.

Besides this superiority in the matter of diffusion, a room illuminated by daylight receives its light from a comparatively large number of square feet of surface, namely, the surface of the windows, whereas in artificial illumination, except in the unusual case of the so-called indirect lighting, i. e., by reflection from the ceiling, the light is received from a surface, the total area of which may be a fraction of a square inch in the case of unshaded electric lamps, or at most a few square feet of surface where diffusing globes are used; so that in the matter of intrinsic brilliancy of the luminous surface there is simply no comparison between natural and artificial illumination.

Another feature not less important in daylight illumination is the fact that, except very near the windows, there is no direct light received from a high elevation. Even when the windows are uncurtained, in most positions in the room the eye can receive light only at a comparatively low inclination, and to avoid receiving it at a high inclination when near the windows, curtains or shades are commonly provided by which the light from above can be excluded, or so reduced in intensity as to be ineffective. In artificial illumination, on the contrary, it is customary to place the light-sources on or near the ceiling, or at least well above the eyes, so that it is in most cases impossible to get in any position in which the eyes do not receive direct light from some position nearly overhead. The eye has adapted itself from countless years of use to the conditions of daylight illumination, and even in the open it is usual to protect the eyes with some sort of shade from the rays falling at a high angle. It is this unusual direction of the light that is undoubtedly accountable for the greater fatigue of the eye in the case of artificial illumination. In many cases at the present time artificial illumination, in point of mere measured brilliancy, exceeds that of daylight, and still no one will think of denying that the best artificial illumination ever produced is far inferior to reasonably good daylight. In laying out the location of light-sources for general illumination, as previously stated, it is permissible to attempt to simulate daylight effects, and the illuminating engineer will have entirely fulfilled his mission if he has reduced, so far as possible, the unavoidable discrepancies and disadvantages inherent in artificial lighting.

In laying out a plan of general illumination the first problem will naturally be the division of the light-sources, i. e., the number of light units to be used in order to secure the total quantity of light required. The question to a considerable extent is one of taste and opinion. With the various reflectors and distributing accessories at present available, it is possible to produce the requisite uniformity of distribution with units of very widely different light-powers. For example, it would be a comparatively simple matter to produce uniform illumination in a large room from arc lamps properly placed and equipped with the proper accesories, or with the ordinary 16-candle-power incandescent lamps, with the so-called "gas arcs," or high power gas burners, or with the smallest size individual incandescent gas burners.

It has been said that "questions of

taste do not admit of argument"—a saying which, while generally true, still has its limitations; there are certain fundamental principles which underlie the subject of æsthetics.

On the subject of large or small units for the production of general illumination, it is argued by some, and apparently with much logic, that the size of the unit should bear some relation to the size of the space illuminated. Thus, in a large hall or store, a comparatively small number of large units, which may be either individual light-sources of large total candle-power, or a cluster or collection of small units having an equally high total light-power, are preferable to a large number of small units distributed uniformly. It is undoubtedly true that an excessive number of light-sources are bewildering to the vision, and have a strong tendency to keep the attention of the eye fixed upon the light-sources instead of upon the objects illuminated. This fact is admitted, probably unconsciously, in special decorations or illuminations of interiors for festive occasions; in such cases the effect particularly sought is to fascinate the eye by the very intricacy of the illumination, rather than to illuminate particular objects. It is obvious that such an arrangement would be very much out of place in a store, where it is desirable that the least possible attention be attracted to the light-source, and the greatest possible attention upon the goods exhibited. As in all other matters where taste is concerned, it is well to avoid extremes. Thus, it would be very poor judgment to attempt to light a large hall or auditorium by a single chandelier or collection of light-sources centrally placed, or even two such units; while, on the other hand, it would be equally undesirable to distribute small units, such as 16-candle-power lamps, uniformly about the ceiling or walls of the room.

Architectural or structural features will have considerable to do in deciding the question of the size of units. This is particularly the case in stores, hotel lobbys and dining-rooms, and occasionally in halls and auditoriums, where the ceiling is structurally divided into a number of panels. In such cases the most natural arrangement is a unit (by which we mean a single fixture, which may contain one or more light-sources) in each panel; at least in the case of panels that are square or approximately so. While other methods are frequently used, the one mentioned is perhaps the safest for general practice.

In general, it should be kept in mind that the units should be so placed that they will serve to accentuate, or at least to conform to the architectural or structural features, and never so as to confuse them. In good architecture the essential structural features should plainly declare themselves; the distribution of the lighting units, being evidently adaptable to structural conditions, should admit this subserviency in an equally unmistakable manner.

Another of the general questions to be considered in placing units is the use of side walls and columns as points of support. Except in very small rooms, a certain number of units attached to, or suspended from the ceiling, are an absolute necessity in the production of uniform illumination; and it is possible in practically all cases to produce such illumination without the use of any side lighting whatever. From the fact that half of the light from units placed about side walls illuminates only the walls, and consequently only the light reflected is utilized for general illumination, it follows that lighting of this kind is far less efficient than overhead lighting. The opinion seems still to prevail quite generally among architects that a certain number of units placed on side walls and columns is essential from the artistic standpoint. This feeling is apparently a relic of the days when candles were the only means of illumination, and when it was necessary to place them at every available point if brilliancy

was to be secured. Instead of side brackets adding to the artistic effect, in most cases they actually detract from it by keeping the eye fixed upon the light-sources rather than the architectural features, and in many instances produce strong contrasts of light and shade which are objectionable. There is one position, however, in which this defect is not produced, and which may be considered a compromise between ceiling and side lighting, and that is the frieze, which architecturally is the line of demarcation between ceiling and side walls. The capitals of columns is a corresponding position. It is possible to use a large number of small units in such a case, as the numerous light points serve to accentuate this line of demarcation, and in a way become a part of the frieze itself.

The height of lighting units from the floor is another general problem requiring careful consideration from the standpoints of both efficiency and appearance. The position of units with reference to the ceiling also affects the apparent height of the ceiling itself. It is a mistake, however, to assume that a low ceiling should have the units placed conspicuously close to it. Such placing simply calls attention to the fact that the ceiling is low, whereas, by allowing a certain distance between ceiling and fixture, the defect is not thus proclaimed, but, on the contrary, a suggestion of sufficient head room is inferred.

The position of the unit should bear a certain proportion to the entire distance from ceiling to floor, rather than be located in strict accordance with the mathematical laws of distribution or efficiency. Thus, in a room with an unusually high ceiling, such as a church, the units or fixtures, if dropped to the position which would be most advantageous from the mathematical standpoint, would give a general effect of disproportion structurally, i. e., would be out of keeping with the general structural features of the building. The same would hold true also if the fixtures were placed comparatively near the ceiling. The proper placing of fixtures in cases where the ceiling is unusually high, of which churches form the principle example, is not an easy matter. Attempts have been made to avoid the difficulty by supporting the units upon standards placed on the floor; this method would seem to offer a possible escape, as in this case the position of the unit is referred to the floor as its point of support, instead of the ceiling, and it can therefore be properly located at a much lower point. This method also avoids the necessity of conforming strictly to structural features, which, in cases of arched ceilings, places very definite limitations upon the points from which units may be properly suspended.

The method of producing general illumination by the reflection of light from sources placed entirely out of range of vision forms an entirely distinct problem from the ordinary distribution of units for direct lighting. The method is available in cases of ceilings of reasonable height, and especially where a rather deep frieze or cove is also present. The method is generally considered to be the most nearly perfect of any plan of artificial lighting, but also the most inefficient; both of which opinions need to be accepted with some reservation. If a moderate general illumination is required, special illumination being provided for special use, the method undoubtedly produces almost ideal results; but the attempt to utilize this method for the production of illumination requiring careful eye work is at least open to serious doubt. Illumination so produced is the artificial equivalent of daylight illumination through a sky-light; and experience seems to prove that this form of illumination is fatiguing to the eyes—which substantiates the statement previously made of the trying effect of light received from high angles.

Daylight Illumination

By O. H. Basquin

IV. SKY ILLUMINATION

FUNDAMENTAL NOTIONS.

When one drops a pebble into a pool of water a set of surface waves start at the point where the pebble strikes and run with uniform speed outward in all directions. The wave-fronts thus seen are circles with ever increasing radii. When a particle of carbon in a gas flame becomes luminous, we think of it as giving off waves whose fronts are spherical and whose radii increase in length with the velocity of light. We may ask ourselves what it is that is passing out from the pebble and from the carbon particle. It is certainly not matter—no material, as we understand that word, and yet something quite definite must be handed along from place to place. That which flows out is spoken of as energy and the continual passing of this energy may be looked upon as a stream or a current of energy.

FIG. 12.

That this is really a current, in much the same sense as that of a stream of air or of water, is manifest when one remembers that the scientific world looks upon energy as a reality or an entity, in the same sense that one generally employs that term with regard to matter or anything else which he believes has an objective existence. It may be interesting to remember that in the long-ago-discarded theory of Sir Isaac Newton this stream of radiant energy was made up of real corpuscles, something like very fine bird shot, which the radiating particle threw off in all directions with the speed of light. Newton, in his fondness for Latin, employed the word "flux" to denote a stream or current. His use of this word may have had nothing to do with its survival, but the fact is that "flux" is now used in the vocabulary of illumination as referring to this stream of radiating energy which affects the sense of sight.

In order to think of unit-current or flux of light we may imagine a source giving out candle-power in all directions. Let this unit-source be surrounded by an imaginary sphere whose surface is everywhere one foot distant from the source. Then we have unit-flux or current of light passing through unit-area on the sphere illumination is flux per unit-area. The unit of illumination is generally spoken of as the "foot-candle" and is the illumination on a normal surface one foot distant from unit-candle* as in the above imagined sphere.

There are a number of ways of varying the illumination, the flux per unit-area. The most patent is that of varying the intensity or candle-power of the source. It is evident that the flux is directly proportional to the candle-power of the source, so that the illumination due to any source is directly proportional to its candle-power.

With a single source and with the surface at right angles to the direction of the radiation, the illumination is inversely proportional to the square of the distance from the source. The total current when added up for the whole spherical surface about the source as center, must be constant, no matter what may be the distance

* For another unit of illumination see page 823 December number of this journal.

from the source. But the area of the surface of the sphere increases with the square of the radius, so that the illumination must decrease as the square of the radius increases.

An apparent exception to this law of the inverse squares is had when a source of light is placed at the focus of a convex lens, as shown in Fig. 13. Before reaching the lens the

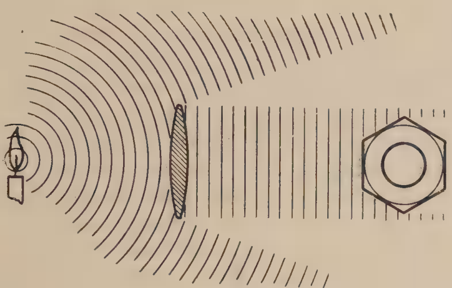


FIG. 13.

wave-fronts are all spherical and the constant flux is distributed over a constantly increasing area, so that up to the lens the flux per unit-area is decreasing. The effect of the lens, however, is to flatten that part of each wave which is transmitted through it, so that as these partial waves move off from the lens they do not increase in area and thus, in so far as these conditions are realized, they give an illumination independent of the distance from the lens. A practical illustration of this arrangement is the searchlight, which gives an approximately constant illumination through a wide range of distance. With the lens, the constant illumination which it gives is inversely proportional to the square of its focal length, i. e., the distance from the source to the lens, so that the law of inverse squares does hold up to the lens, if not beyond.

A line drawn at right angles to a surface is spoken of as "normal to that surface" or as being "a normal to the surface." The angle between this normal and the direction from which light is approaching a surface is spoken of as the "angle of incidence." We have thus far assumed that the angle of incidence has been zero, i. e., that the light has been coming along the normal. In Fig. 13 the light from the lens is shown falling upon three faces of a hexagon nut. On one face this angle of incidence is zero, and for two of the faces this angle is sixty degrees. The first face is receiving the maximum amount of the light current. Since the cosine of sixty degrees is one-half, it is evident that each of the other faces is receiving only half the flux that the first face receives. Since their areas are the same their illuminations will be in the ratio of 1 to one-half. In general it is evident that the surface illumination derived from any particular light current is proportional to the cosine of the angle of incidence of that current.

At any one instant in a stream of water or of air the current always has a particular direction at every point and only one direction. If a certain water-main is discharging twice as rapidly today as yesterday, we are sure that the average speed of the water in the pipe has been doubled. These analogies do not hold for light currents. The speed of transmission has nothing to do with the intensity of the current, and currents in different directions can occupy the same space apparently without interfering one with another. When we think of the conditions for unit illumination as pictured above, we have a single light current at any one point and that current has one particular direction at each point, but in general in the actual case, we have a very large number of sources of radiation and for each point in space we have a large number of currents passing, each in its own particular direction. As these effects are, in general, independent of one another, the illumination of a surface is to be found as the sum of the illuminations due to the several currents taken separately.

In the study of light waves many cases such as the colors of soap films,

pearls, etc., are well known in which currents in different directions interfere in space and their effects cannot be added together in this way, but all these phenomena are very special cases, and, while intensely interesting, they are of no importance in the study of illumination.

To summarize with respect to the illumination produced on any surface by point-sources of radiation, we find that for each source it is proportional (1) to the intensity or candle-power of that source, (2) to the cosine of the angle of incidence, and (3) to the reciprocal of the square of the distance from the source, while (4) the whole illumination is the sum of the partial illuminations produced by the several sources.

Thus far we have considered only radiation from point-sources. We must now extend our attention to illumination from luminous surfaces, such as a strip of red hot metal. We may think of the section of this strip of metal as made up of an irregular collection of small opaque particles somewhat as shown in Fig. 14. On

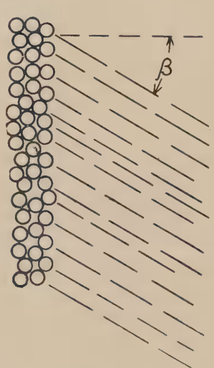


FIG. 14.

account of the extreme irregularity of the surface, it is evident that if one is looking at this collection, the number of particles which he can see depends upon the direction from which he looks. If he looks along the normal he will see the greatest number, while if he looks along a line lying in the plane of the surface he can see only the end particles. Between these extremes the number which he can see is proportional, very approximately at least, to the cosine of the angle (β) which this direction of view makes with the normal to the surface.

Now if we think of each of these particles as a point-source of radiation, then the current or flux of light will be greatest along the normal to the surface because the radiation from the largest number of particles is able to get away from the surface in this direction. For other directions the flux from the more deeply imbedded particles is more or less interfered with by their more projecting neighbors. The total flux in any direction is thus approximately proportional to the cosine of the angle of emergence (β). This cosine proportionally depends thus upon the roughness of the surface and upon the opacity of the particles. As our immediate application of this principle is to clouds, there can be no question as to the roughness of their surface or as to the opacity of the particles, because of the violent refraction of light striking drops of water.

We have already defined the brightness of a small surface as the ratio of its normal candle-power to its area. This is limited strictly to the direction along the normal, because the brightness may be different in some other direction. Let us assume that the surface in question conforms to the above cosine law and let us inquire what its brightness will be in a direction, making an angle (β) with the normal. We may define this

FIG. 15.

brightness as its candle-power in this direction divided by its projected area in this direction. The projected area in a direction (β) is seen in Fig. 15 to be its true area multiplied by cosine B. The candle-power, being proportional to the flux, is also proportional to the same cosine. Hence the brightness is independent of direction, the rough surface has the same brightness in all directions.

This independence between brightness and angle of emergence is known as Lambert's law,* inasmuch as he first pointed it out about 1760, and noted that if this law was not approximately true the disc of the sun would be very much brighter near its edge than at its center.

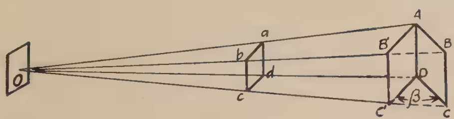


FIG. 16.

In Fig. 16, let ABCD be a luminous surface conforming to Lambert's law, and let us interest ourselves in the illumination which it produces on the small surface shown at the point (o). We shall think of ABCD as a very small surface in comparison with its distance from (o). By Lambert's law we may replace this surface by its projection in the direction of (o), provided this projected area AB′C′D has the same brightness as the original surface ABCD. Now by the law of inverse squares, applied backwards, we may replace this area AB′C′D by the parallel and co-normal area *abcd*, of the same brightness as before but with linear dimensions reduced in proportion as it is nearer to (o). These changes from ABCD to *abcd* have introduced no change in the illumination at (o).

Let us now apply this method of thinking to the clouds and sky. The real sky is made up of clouds both far and near at a considerable elevation above the earth's surface. The child thinks of the sky as the interior of a great dome coming down to touch the earth not so very far away. Let us see if these views are equivalent as far as illumination goes. In the first place, if we keep the brightness constant we may replace all cloud faces by their projections in our direction of sight, and in the second place we may arrange all these projections at a uniform distance away, sliding each along on its normal and making its linear dimensions change in the same ratio as its distance away changes. By this means we are able in thought to transform the real sky into the spherical one seen by the child, and we have done this without changing the illumination which it produces at the center. Because this spherical sky lends itself to certain easy methods of treating the problem of illumination, we shall generally find it convenient to adhere to this mental picture in all which follows.

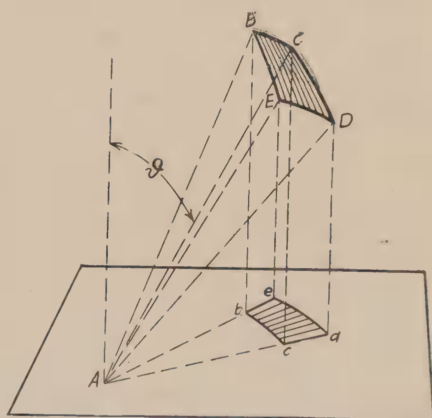


FIG. 17.

In Figure 17, BCDE is intended to represent an element, i. e., a very small part, of this bright spherical surface which we now call the sky. The center of the sphere is at A, and we wish to find the illumination on a horizontal surface at A due to this one element of sky. Let B be the brightness of the sky in candles per square foot. Let f' be the area of the

* Lambert's Photometric, translated by E. Anding, No. 31-33 of Ostwald's Klassiker.

element of sky which is so small that each of the lines AB, AE, etc., representing the radius R, make the same angle (θ) with the normal. We shall at present measure R in feet and f' in square feet. From what we have seen above we know that the illumination, i, on the horizontal surface at A due to the element of sky is given by the expression,

$$i = B \frac{f'}{R^2} \cos \theta$$

Now since θ is the angle between the normal to the sky-element and the normal to the plane, it must also be the angle between the element and the plane. We see then that $f' \cos\theta$ is the projection of the element on the plane. In Fig. 17 the area *bcde* represents the projection of BCDE on the plane in question. If this projection of the sky element be called f, then we have,

$$bcde = f' \cos \theta = f$$

Making this substitution in the expression for the element of illumination we have,

$$i = \frac{Bf}{R^2}$$

This equation means that the illumination at A due to the area f' of sky is equal to the product of the sky-brightness B, in candles per square foot, into the projected area, f, in square feet, divided by the square of the radius, R, in feet.

We now have the expression for the illumination at A of a single very small element of sky. That for every other sky-element will be of the same form, and the whole illumination will be obtained by adding together the several partial illuminations. If we have n different elements of sky, we may express this whole resultant illumination as,

$$I = Bf_1/R^2 + Bf_2/R^2 + Bf_3/R^2 + \dots\dots + Bf_n/R^2$$

In this expression for the total illumination we notice that both B and R^2 are constants, so we may write,

$$I = \frac{B}{R^2} (f_1 + f_2 + f_3 + \dots\dots\dots + f_n$$

Now these f's are the projections on the plane in question of the several sky-elements, and it is evident that the sum of these projections is just the same as the projection on this plane of the whole visible sky taken at one time. Let the projection of the whole sky be represented by F, then we know that

$$F = f_1 + f_2 + f_3 + \dots\dots\dots\dots + f_n$$

Inserting this in our expression for the total illumination it becomes,

$$I \ \frac{BF}{R^2} \dots\dots\dots\dots\dots\dots \text{Equation 4}$$

This equation means that the illumination due to the sky at any point of a surface is equal to the product of the sky brightness and the area of the sky projected on that surface, divided by the square of the radius of the sky.

It may be interesting at this point to inquire what the illumination is upon a horizontal surface upon which light from the whole sky is free to fall, i. e., where there are no buildings, trees, etc., cutting off the skylight from this surface. F is the projected area of the whole sky upon the horizontal plane. Whatever may be the radius, R, of the sky, it is evident that the projected area, F, will be the area of the circle which the sky cuts out from this horizontal plane. The area of this circle is $\pi R^2 = F$. R then disappears from our value for the illumination, leaving,

$$I = \pi B.$$

If we take B equal to 250 candles per square foot, the numerical value for I comes out about 800 foot-candles.

It will be evident that the illumination due to the sky upon one side of a vertical surface will be just one-half that for the horizontal surface.

(*To be continued.*)

The Absorption of the Earth's Atmosphere for Light of Different Colors

By J. S. Dow

During the last six months there has been a prolonged discussion in the columns of the *Electrical Review,* London, on the question, "Which are the light rays which penetrate the atmosphere best, those of great wave length at the red end of the spectrum, or the blue-violet rays of short wave length?" In this article the writer proposes to follow this discussion, giving the references to the various letters, etc., which have been published on the subject, in order that those who care to do so, may follow out the subject in detail.

The matter is now of practical interest because of the wide differences in color which are to be met with in the case of such illuminants as the flame arc and the mercury-vapor lamp. We are now approaching the stage of illumination when the spectral composition of illuminants will be completely under control, and will be varied according to the work the lamp is intended to perform. In lamps intended for lighthouse illumination, for instance, preference will be given to those rays which are particularly suitable for the purpose of penetrating fogs and mists.

Before entering on this discussion it is well to make certain exactly what is meant by the "penetrating power" of a light.

By this term the writer means simply the capability of the rays issuing from a source to make their way through the atmosphere and the greater the "penetrating power" of a light the less the loss of illumination in doing so. The penetrating power, thus defined, has nothing to do with the physiological peculiarities of the eye as regards color. It is to be noted that the penetrating power of a light should be judged by its power of illuminating a surface (preferably at a fixed distance from the eye, as in a photometer). The distance at which a light itself can be seen depends on some physiological facts connected with the sensitiveness of the retina of the eye to light of different colors, and is not, therefore, a fair method of judging penetrating power, though, of course, this question is also of importance.

The discussion originated in a letter from the Kitson Light Company (*Electrical Review,* July 27, 1906), pointing out that their incandescent gas lamps have, in several cases, proved much more satisfactory than the old white carbon arcs for lighthouse work. The explanation given was that the incandescent gas lamp was richer in the red and yellow rays than the arc, and that the rays at the red end of the spectrum penetrated the atmosphere best.

This letter drew a reply from Mr. Bastian (*Electrical Review,* August 3, 1906), who is well known as a maker of mercury-vapor lamps. Mr. Bastian declared that the penetrating qualities of the Kitson lamp were derived from the fact that the light is distributed over a greater area in an incandescent mantle than in an arc. From his experience of the mercury-vapor lamp he maintained that green and blue rays penetrate the atmosphere best, and advanced as further evidence in favor of his opinion, the fact that distant objects, such as woods and mountains, appear blue.

Mr. Marinier (*Electrical Review,* August 17, 1906), now drew Mr. Bastian's attention to the fact that the red color of the setting sun was usually explained on the ground that

the rays of the sun had to pierce through a greater thickness of atmosphere, and that the red rays were blocked less than others. According to Mr. Bastian's theory the setting sun should appear blue.

Mr. Marinier showed further that the blue appearance of distant objects in the evening was due to the fact that the minute particles of dust in the air did not allow the blue rays from the sun to pass through. These rays were reflected hither and thither in the atmosphere, thus producing a blue haze while such rays as *did* come through from the sun had a golden or orange color, which by contrast intensified the blue appearance of the haze.

Solutions of chalk or silver chloride—any solution containing small opaque objects in suspension—show the same effect. By reflected light they appear bluish, but the light transmitted is reddish.

A new writer "Sol," in a series of letters, (*Electrical Review*, September 14, October 12, November 23, and December 7, 1906), upheld this view. He pointed out that it was invariably *dark* distant objects—woods and mountains—which appeared blue. The blue appearance must, therefore, arise in the intervening medium; it could not possibly be blue light which had traveled to the observer from the distant objects. Mr. Bastian, however (*Electrical Review*, August 31, October 5, October 26, 1906), was unconvinced. He maintained that the color of the setting sun was a "refraction" effect in which the red end of the spectrum reached us first, to be followed later by the blueness of twilight. He disbelieved in the theory that the air contained particles in suspension sufficiently minute to be comparable with the wave-length of light. He argued that the absorption of the air was mainly due to water-vapor, which, he thought should transmit blue light best. Finally he declared that he had found by experiment that the light from his mercury lamp penetrated fogs much better than an arc, in spite of its pronounced green and blue constituents.

The general belief up till now has been unquestionably that rays of long wave-legnth penetrated the atmosphere best, and the interesting suggestions of Mr. Bastian induced the writer to contribute an article to the *Electrical Review* (November 2, 1906), in which he discussed the question in detail and gave a resumè of the evidence in favor of the orthodox opinion quoted above.

Mr. Bastian's suggestions seem to have been first put forward in a paper before the Glasgow section of the Institution of Electrical Engineers (*Electrical Review*, June 8, 1906), and to have been mainly founded on the results of an experiment with the mercury arc.

This result was briefly as follows: The candle-power of the mercury lamp was found to vary enormously for different distances between the mercury lamp and the photometer. When the lamp was 1.86 metres from the photometer screen it had a candle-power of 14. But when the lamp was removed to a distance of 21.5 metres from the photometer it had apparently, a candle-power of 25.

Mr. Bastian, in the paper referred to, tried to explain this curious result on the following two suppositions:

(1) That the difference in intrinsic light-density of the two sources results in the light from the source of smaller intrinsic light density (the mercury-vapor lamp) being absorbed to a less degree by the atmosphere.

(2) That rays from the blue end of the spectrum penetrate the atmosphere best, and that this fact also favored the mercury lamp at the greater distance.

Now, whether they exist or no, to the writer it seems impossible that either of these effects could cause a change of this magnitude.

For what would happen if the absorption of only twenty metres of ordinary atmosphere could in any way alter the candle-power of a lamp from 25 to 14? It would mean that

the inverse square law was quite inapplicable to the calculation of the ground illumination from a lamp.

It would mean that not only lights of different colors but even lights of the same color and different light-density, could not be compared at different distances on a photometrical bench, with consistent results.

But flame standards can be compared against glow lamp standards at different distances with consistent results, and (unless the illumination is very low) the writer has found the same to be true for lights of different color.

In short, the writer believes that the experiments quoted by him in this article showed that the influence of atmospheric absorption on indoor photometrical measurements is of trifling importance.

What, then, was the explanation of Mr. Bastian's experiment? In the article referred to, the writer gave his reasons for believing that it was probably due to the Purkinje effect. Unfortunately, Mr. Bastian, while refusing to accept the Purkinje effect as an explanation, did not state very exactly the conditions under which the experiment was made. He did not actually state the exact nature of the lamp compared against the mercury lamp, but it was, apparently, a glow lamp.

However, it seems certain that if this lamp differed much in color from the Mercury lamp, the Purkinje effect must have been of importance at the extremely weak illumination Mr Bastian used. For, taking the *maximum* value of the candle-power of the mercury lamp, the illumination of the photometer screen works out to $25 \div (21.5)^2 = 0.055$ candle-metres, about.

At illuminations like this results hundreds of per cent different from those at normal illuminations are easily obtained. For instance, Sir William Abney shows that when the brightness of the yellow in an arc spectrum is about 1-candle-foot, the maximum luminosity is in the yellow. But when the illumination was reduced to $1 \div 132.5$ Hefner-candle-feet (i. e., about 0.06 candle-metres) the maximum luminosity is shifted right out into the green. The luminosity curve is entirely altered.

Weak illuminations like this, therefore, tend to accentuate the blue-green portion of the spectrum and would, therefore, favor such a source of light as the mercury-vapor lamp.

Any experiment which is intended to investigate the penetrating properties of a light must be made independent of physiological conditions by comparing two lights of exactly the same color.

The writer, therefore, submits that Mr. Bastian's experiment cannot be taken as evidence in favor of either of his suggestions.

In every day life we meet with many phenomena which seem to show that red rays penetrate best. Reference has already been made to the red color of the setting sun and Mr. Bastian's explanation of this fact. But, if the sun, when high in the heavens, is obscured by a mist, or smoke or fog or any other collection of minute opaque particles, the issuing rays of light again become orange or even red in color.

The only fair test of the absorption of the atmosphere is the color of luminous distant objects. The writer has noticed that, when the atmosphere is misty, the more distant of a row of arc light or incandescent mantles, invariably appear redder and redder in the distance. On the other hand dark distant objects often appear blue, because the veil of atmosphere in front of them is colored blue by the blue rays from the sun. These are turned aside by the minute suspended particles in the air, and reflected hither and thither among them.

It can be mathematically shown that the fact that light travels in straight lines is simply a consequence of the shortness of the wave-length.

Light *can*, however, "turn corners" to a slight extent and it is supposed that rays of red light, being of great-

er wave-length, can turn corners better than the violet rays, and so work their way better amid the suspended minute particles of a fog.

Electromagnetic waves, which are merely light waves of very great wave-length, have such good penetrating power, that, so far from being stopped by a fog, they are able to penetrate even solid obstacles.

On the other hand the ultra-violet rays of short wave-length beyond the blue and violet are so easily stopped by the atmosphere that their spectroscopic detection is extremely difficult. So difficult, in fact, that Schumann obtained photographs of lines in the extreme ultra-violet only by working with a high vacuum which allowed the rays to pass from the source to the photographic plate without traversing any air at all.

Mr. Bastian in his reply (*Electrical Review,* November 23 and 30), did not seriously attempt to refute the writer's suggested explanation of his experiments, but turned his attention to the other arguments from natural phenomena. He asserted, in the first place, that it was not strictly logical to argue about *light* waves from the behavior of electromagnetic and ultraviolet waves.

By this time, he had apparently accepted the idea that the blueness of distant objects was caused by the irregular reflection of blue rays by the intervening atmosphere. But he argued that a transparent body which reflects blue light best, must also transmit blue light best, reasoning from the analogy of the leaves of trees which both transmit and reflect green light. To those who believe that the absorption of the atmosphere is due chiefly to finely divided and suspended particles of dust, this analogy did not, of course, appeal. It must be questioned, too, whether the color of the reflected light from colored transparent objects is not due to its having partially penetrated into the object before reflection.

However, having expressed his belief in the blue-transmitting powers of the atmosphere, Mr. Bastian now found it necessary to explain why the sun, on a misty day, looks red. His explanation was certainly ingenious. He suggested that the sun must contain much more red light than blue.

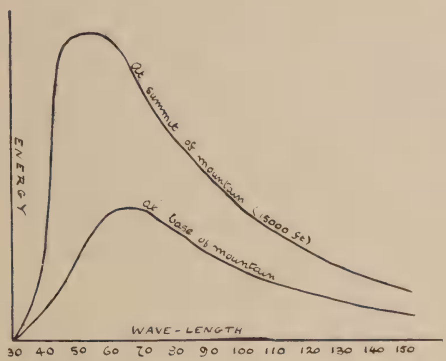
"We will imagine an illuminant composed of 60 per cent red light, 30 per cent yellow light, and 10 per cent blue light, and, for the sake of argument, we will represent the conductivity of the atmosphere for blue light by the figure 100, for yellow light 90 and for red light 80, and it is obvious that this illuminant, seen through a sufficient thickness of atmosphere would appear red, owing to the fact that there is most red light in its composition and notwithstanding the fact that blue light is conducted somewhat better than the other two colors."

To the author this is not so very obvious, but it is certain that this explanation is quite at variance with all that is known about the sun.

It is true that most of our artificial lights contain more red than violet, but this is simply a consequence of their low temperatures of incandescence. In the carbon-filament lamp the maximum energy in the spectrum is right out in the infra red portions. The increase in temperature of the Nernst lamp results in this maximum being shifted nearer the visible portion of the spectrum, while it is believed that, at the enormous temperature of the sun, the maximum is shifted right across into the ultraviolet portion of the spectrum with the result that the sun should contain more blue energy than red.

This result was confirmed long ago by the experiments of Professor Langley (described in a lecture before the Royal Institution, 1885). Professor Langley mapped out the energy of the solar spectrum at the base and also at the summit of Mt. Whitney (15,000 feet), one of the highest peaks in the Sierra Nevadas, where the atmospheric absorption is, of course, very much less. (It is estimated, indeed, that one-half the total mass of the atmosphere lies within the first

four miles from the earth.) The general nature of his results is shown in the diagram.



Professor Langley's curves showing the difference in the distribution of energy in the solar spectrum at the base and at the summit of Mt Whitney (15000 ft)

At the summit of Mt. Whitney the energy increased far more rapidly in the blue than in the red, and the point of maximum energy had already been shifted into the extreme blue of the visible spectrum. Professor Langley calculated that if the absorbing influence of the earth's atmosphere were removed, the sun would appear blue; and the point of maximum energy would be shifted into the ultra-violet.

In conclusion, therefore, the author thinks that the existing evidence is strongly in favor of the assumption that rays of great wave-length penetrate the atmosphere best. It is only fair to note that Professor Langley purposely chose for his experiments a district comparatively free from fogs.

In a thick yellow fog the condition of things must be different, but probably in a direction still more unfavorable to blue light.

On the other hand, it is quite possible that there may be other factors which are still more important in the design of a lamp for use in a fog.

The writer is inclined to agree with Mr. Bastian that the notorious bad qualities of the white arcs in a fog cannot be wholly explained on the ground of its spectral composition, and though Mr. Bastian's interesting theory as to the importance of "light-density" in a source, cannot be regarded as a trustworthy deduction from Mr. Bastian's experiments, yet the suggestion is worth consideration.

Inverted Incandescent Gas Burners

By Chas. W. Hastings.

The popularity and excellence of the inverted gas burner is one of the most astonishing developments of the science of gas lighting. Prior to the autumn of 1904 the burner was practically unknown, the few that had been made, were incomplete, bad in construction and looked askance at by most of those who had been privileged to see them.

Inverted burners, however, were not to remain in obscurity for long, for at the very popular Gas Exhibition, held at Earls Court, London, England, in the latter part of the year 1904, there were several excellent exhibits, and inverted burners with their chaste fittings and ethereal glassware were one of the sensations of that very successful exhibition.

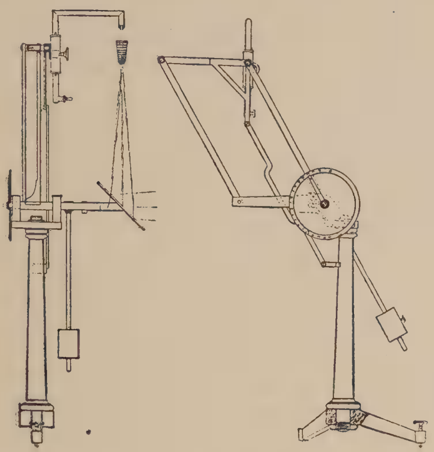
There is practically no history to this burner; it became a success almost at once and revolutionized the fashion in gas fittings in place of heavy, ponderous chandeliers and brackets. Makers turned their attention to the adapting of electric light fittings to the necessities of the inverted burners. Especially this was, and is, the case with single central lights and brackets. We will not, however, in this article attempt to deal with the question of fittings but reserve it for a future number.

Looking through the files of the technical press we find only one really instructive article upon the science or art of illumination by means of inverted burners, and that appeared in 1905 in the columns of the *Journal fur Gasbeleuchtung*. It was originally contributed in the form of a paper before a meeting of the members of the German Association of Gas and Water Engineers; and is from the pen of the gifted scientist, Professor H. Drehschmidt, chemist of the Berlin Municipal Gas Undertaking.

Commenting upon the position occupied by the upright incandescent gas burner he drew attention to the advantage of the electric arc light, by reason of the fact that it emits the greater part of its light in a downward direction, whereas with the ordinary form of incandescent gas burner most of the light is upwards. By means of reflectors, screens, and globes the best has been made of this unfavorably distributed light. Some reflectors in use only diverted 6.5 per cent of the upward light but the Holophane system adds a more effective value to the diverted light. Recently, he says, a more satisfactory distribution of light evolved has been secured through the medium of the inverted incandescent gas burner.

Opinions appear, at that time, to have differed very much as to the benefits to be derived by the use of this new burner; in Germany its application was very restricted, our prominent technical man going to the length of saying it was a fraud. Even in Great Britain, as recently as May, 1906, Mr. H. O'Connor, an authority upon gas matters, said he "supposed that there was nothing so unscientific with which gas is used as the inverted burner. It was entirely opposed to all the principles of combustion. They were trying to make the flame burn downwards instead of upwards. They were making it do so and they were taking what heat they could get from it to heat the mantle; but it was entirely against all theories of heat rising and of the issuing of gas." Be this as it may, the inverted gas burner is very much with us, it has caught the public's fancy, and, we believe, whether the system is perfect or imperfect, the inverted burner has come to stay.

Returning to Professor Drehschmidt's experiments: He proceeded to test the illuminating power of the burners at different angles, for which purpose he used the ap-



FIGS. 1 AND 2

paratus illustrated in Figs. 1 and 2, which are thus described: A mirror set at an angle of forty-five degrees is fixed on a revolvable axle, which is firmly attached to a parallelogram built up of rods. To one angle of this parallelogram is fixed the arrangement which supports the burner. Thus when the parallelogram is rotated, the burner retains its vertical position. The light which falls on the mirror, at any angle of radiation, which angle is determined by the position of the parallelogram, is reflected horizontally. If the apparatus, therefore, is set up so that this light is reflected in the direction of the axis of a photometer-bar, its intensity can be measured as readily and as quickly as a measurement of horizontal illuminating power.

With regard to the form of the burner and mantle, the inventor, says the professor, appears to have thought that the combustion gases must pass through the mantle in order to give up their heat to it and so raise it to incandescence. This idea still pervades the construction of some diverted burners, but the later types have the burner mouth of much smaller diameter than the mantle, so that there is a space between burner and mantle for the escape of the heated gases. Should, however, this space be closely filled up, the gases will penetrate the mantle, a considerable loss of illuminating power will ensue and the flame will become smoky. If a smoking burner is watched it will be seen that the soot deposits on the burner tube, a certain indication that the combustion gases have passed between the burner tube and the mantle ring. A properly constructed inverted burner should, therefore, provide, between the mantle and the mouth of the burner, a free space which must not be too narrow, but admit the ready passage of the gases produced by the combustion of the gas.

The earliest form of mantle used on the inverted burner was open-ended, like those used on the upright burner, but a mantle that was closed below was soon adopted; the upper or open side was firmly secured by asbestos thread, a ring of metal, magnesia or other composition; the ring had projections for hanging the mantle on; a variety of methods were adopted to secure the mantle to the burner. These burners did not find much favor, even though they were free from the evil of lighting-back. They, as a rule, emitted an unpleasant smell and injured fittings by the escape of the products of combustion. The next advance was the introduction above the mantle of a deflecting plate as guide, made variably in metal, porcelain or other material with the object of diverting the products so that they passed well outside the burner.

The mantles were protected by a variety of glass globes or shades, which, in addition, gave the necessary current of air. This draught was sometimes increased by placing a chimney tube above the mantle, but such an arrangement spoiled the appearance of the burner.

Another point to be carefully considered in the use of inverted burners is the control of the gas supply. The inflow of primary air will have to be regulated in accordance with both the quality and pressure of gas supplied; it is most advantageous to use gas of

uniform pressure. The inverted burner, in its early form, was fitted with short mantles, and the opinion was very freely expressed that except for local light, over tables, reading desks, etc., they would be of little use, and were not in any way suitable for the lighting of rooms. Experience taught the makers that with lengthened mantles more lateral illumination was possible and much higher efficiency obtained.

We will now go back to Professor Drehschmidt's experiments of which we are able to give diagrams.

The burners used were, G, an old inverted burner without any proper lateral discharge of the products of combustion; P, a burner in which the products were carried away on all sides by means of a deflecting plate; W, had a chimney tube and a hemispherical globe closed below; while M represents a burner in which the primary air has been previously heated and the products of combustion carried off on one side only.

FIG. 3.

Fig. 3 shows the distribution of the light of all fair burners, and of the ordinary Welsbach burner in different directions. The actual intensity has been disregarded, and the illuminating power in a horizontal direction is taken as equal in every case to 100. With a Welsbach burner only 45.8 per cent of the light is thrown below the horizontal; whereas with the inverted burner W the proportion is 63.1 per cent, and with the M burner 65.5 per cent. The distribution of the light over the whole lower hemisphere was also most satisfactory; with the burner M, not only was the radiation directly downwards good, but the radiation sideways was always good enough to afford satisfactory general illumination and even upwards there was sufficient light from this burner to prevent the ceiling of the room being in darkness. If it were desired this upward light could be deflected downwards by means of a reflector which can be fitted more satisfactorily to the inverted than to the upright incandescent gas light.

Fig. 4 is perhaps a still more interesting diagram. It shows, graphically, the light in Hefner units* obtained per 100 litres, 3.53 cubic feet, of gas consumed in the different burners. It will be seen from this diagram that, with the exception of burner G the inverted considerably surpasses the ordinary incandescent light in regard not only the lower hemispherical light, but even to the total spherical brightness. The superiority of the inverted burner is its most essential particular, viz.: mean lower hemispherical brightness is apparent, from the gas consumption per candle hour, which amounts to 0.08 cubic foot with the ordinary upright incandescent burner, and 0.043 cubic foot with the best inverted burner. Professor Drehschmidt adds, it is unnecessary to discuss the curves further, as they show, he says, clearly the great superiority of the inverted burner.

Still, he says, it will be profitable

* One Hefner per 100 litres equal very nearly ¼ candle per cubic foot.

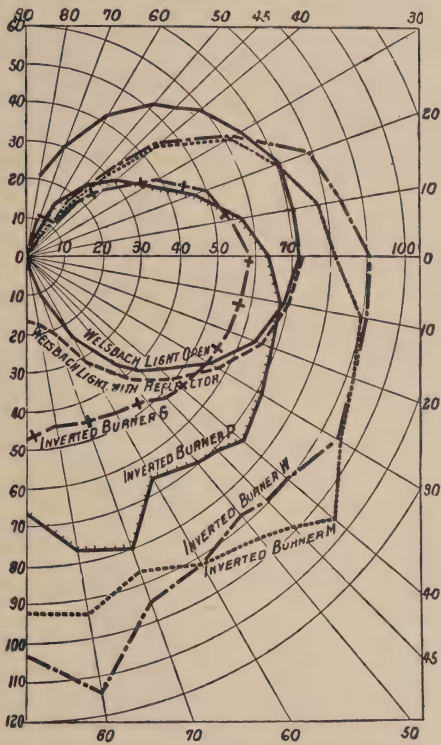


FIG. 4.

to compare the distribution of the light with that of the electric light, which is, of course, the principal competitor with incandescent gas lighting and to see how the inverted gas burner stands with regard to the competition in that particular, as distinct from cost. This comparison is shown diagramatically in Fig. 5. The horizontal illuminating power is taken as equal to 100, except in the case of the flame arc light, of which the horizontal value is very small. Its greatest lighting power is at 90 degrees below the horizontal; and this has been taken for the purpose of the diagram, as equal to that of an inverted burner at 80 degrees below.

It will be noted that the carbon-filament electric glow lamp, the Osmium and the Nernst lamp with vertical filament, all develop nearly as much light above as below the horizontal, and so stand at a palapable disadvantage when compared with the inverted gas burner. The flame arc light, although it emits all its light downwards, is inferior to the inverted gas light, because it has too little lateral lighting power and is not fitted for general illumination of either rooms or streets. The ordinary electric arc light develops most light in the lower hemisphere; being strongest at an angle of thirty degrees below the horizontal; both horizontally and vertically downwards it is relatively inferior to inverted gas lighting. Professor Drehschmidt gives it as his opinion that the curves demonstrate that the inverted gas light of the best type distributes its light far more favorably than any kind of electric light.

The later form of inverted gas burners afford more lateral illumination than the earlier ones, and so it seemed worth while to study their ef-

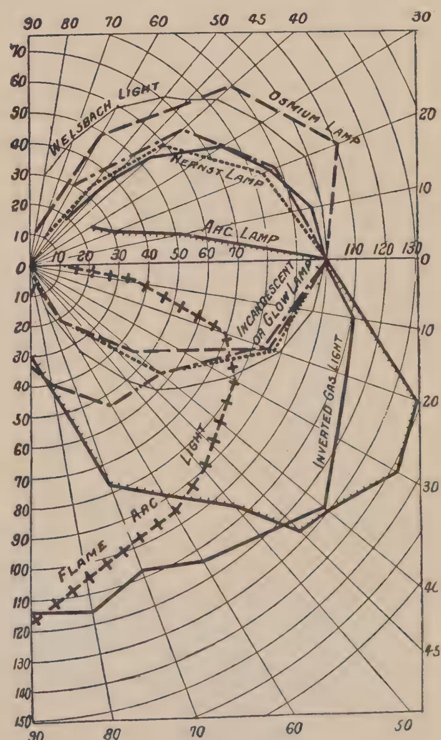


FIG. 5.

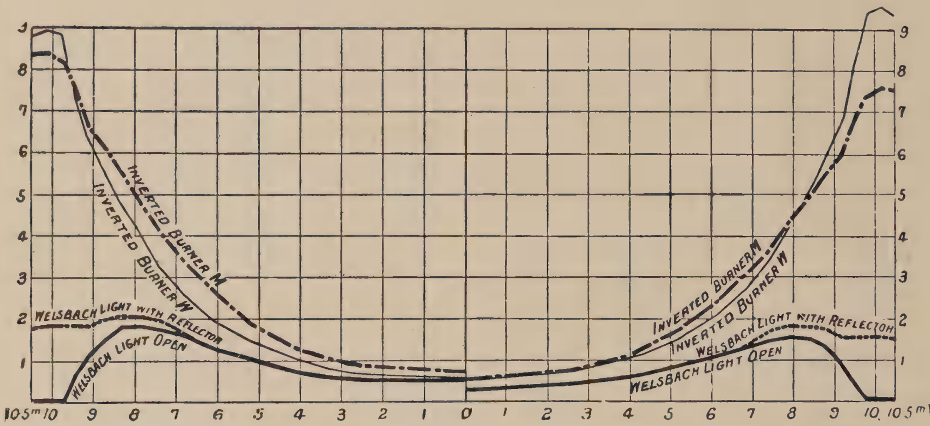


FIG. 6.

fectiveness for street lighting. Fig. 6 shows graphically the illumination of the surface between lanterns placed twenty-one meters (about seventy feet) apart and with the light about twelve feet from the ground for the inverted burners referred to as W and M, and ordinary incandescent gas burners, with and without reflectors. The half of Fig. 6, on the left hand, refers to the burners with horizontal illuminating power taken as equal to 100, and the right hand half to the same burners at their absolute illuminating power. In both cases the inverted burner is shown to be superior.

So much for the inverted burners from the scientific side, and in comparison with other means of illumination. We will now make some short reference to the inverted gas burners that were exhibited in London in 1904. Fig. 7 illustrates the globe inverted burner complete with 6-inch adapter fitted to an ordinary gas bracket. These burners were made vertical as seen in the illustration or could be inclined at an angle to suit any special requirements. In this burner the gas and air were preheated prior to burning. Fig. 8 shows the method adopted for hanging the mantle in this particular form of burner.

Fig. 9 is claimed to be the original inverted gas burner and to give the maximum light with the minimum consumption of gas. Fig. 10 shows us a miniature burner known as the Bijou, both burners were manufactured by the New Inverted Gas Lamp Company, of whose later burners we shall presently have something to say.

FIG. 7.—THE GLOBE INVERTED BURNER COMPLETE WITH 6 INCH ADAPTER FITTED TO AN ORDINARY GAS BRACKET.

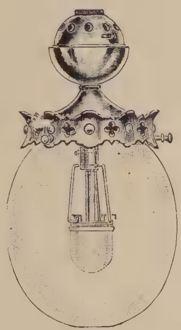


FIG. 8.

FIG. 11.

FIG. 13.

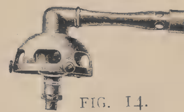


FIG. 14.

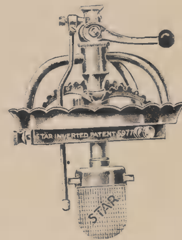


FIG. 19.

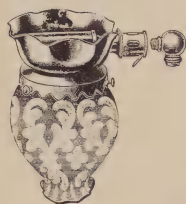


FIG. 17.

FIG 18.

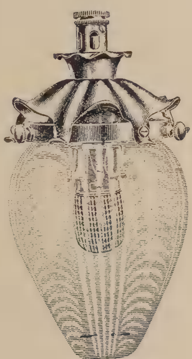


FIG. 16.

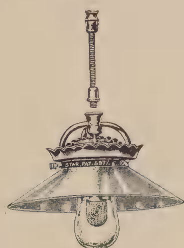


FIG. 20.

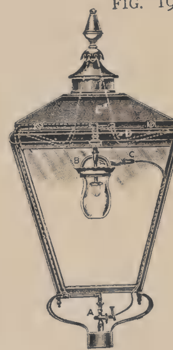


FIG 21.

FIG 9.—THE ORIGINAL INVERTED GAS BURNER.

FIG 10.—THE BIJOU.

In Fig. 11 we have the earliest attempt to produce an inverted cluster lamp, for which the makers, Messrs. I. & W. B. Smith, claimed that it would give "a larger volume of light, better diffused and steadier than any electric arc, at a fraction of the cost." The modesty of the claim will be appreciated, but we must add that the firm have done excellent work as illuminating engineers, especially in connection with street-lighting and outside lamps.

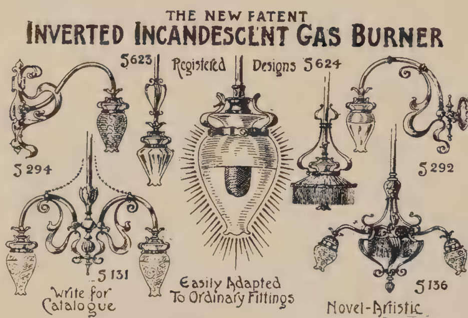


FIG. 12.

The cluster of fittings shown in Fig. 12, are included in order to illustrate the type of brackets and pendants that were at that time being designed for the use of inverted gas burners by the Sunlight and Safety Lamp Company.

There were only two other exhibitions of inverted burners at the 1904 Exhibition. Messrs. Wright & Butler showed their "Darwin" burner, and the Star Inverted Incandescent Burner Company. The specialties of both these firms are prominently before the public and will be reviewed in this article.

During the last few weeks and in part to gather information for the columns of THE ILLUMINATING ENGINEER, the writer visited the principal manufacturers of inverted burners in London and Birmingham.

Perhaps the most novel form is that known as the "Electroform," Fig. 13. It will be noted that in shape it is quite a departure from what has become almost a strictly pea shape. It is claimed that it is the only inverted light which burns at the same angle as the electric light. The illustration shows the position of the mantle, the globe is closed at the bottom, the Bunsen tube is isolated from the burner so that lighting-back is practically impossible. The construction of the Bunsen provides for three fresh air supplies, the gas supply can be regulated by the milled head at the top. Two or three burners can be fitted to one bracket, or to each arm of a pendant all regulated with one regulator. With this form of burner no adapter is necessary. The illumination both lateral and vertical, is of great intensity. With a consumption of 2½ cubic feet a duty of seventy to eighty candles is obtained.

Fig. 14 illustrates one of the latest forms of inverted burners manufactured by the Welsbach Incandescent Gas Light Company, known as the "Angle" burner. The drawing represents this particular form as used for a "Gem" lamp and mantle. The principal advantage is that the products of combustion cannot be

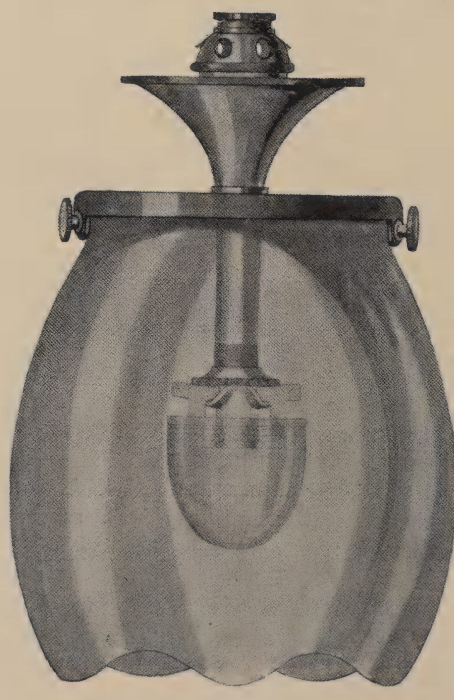


FIG. 15.—THE "IDEAL"

drawn into the mixing chamber or tube. For these Angle burners special pendants and brackets have been designed, in order to harmonize with the horizontal arm of the burner. This form of burner is also adaptable for outdoor lighting.

The "Ideal," Fig. 15, is the invention of Messrs. Cope and Timmins, of Birmingham. In the head of the fitting a regulator is arranged which adjusts the gas supply. A special metal disc on the down tube fixes the mantle securely in position, so that it cannot fall although the burner be fixed at an angle. The burners are made in several sizes and have a consumption of gas ranging from 3½ to 1½ cubic feet per hour.

A popular burner is the "Darwin," made by Messrs. Wright and Butler, of London and Birmingham; the firm has taken much care in the production of their inverted burners. Fig. 16 shows the general form. The burner has a special mixing chamber which the inventors claim to be the reason for so high an efficiency being obtained. Mr. Harold E. Copp, Engineer of the West Brauwich Corporation Gas Works, made a series of exhaustive tests, with a standard 60-inch Letheby type photometer and Harcourt's standard 10-candle Pentane lamp. The observations, of which we give a summary, were taken by Simmance and Abady's flicker photometer. The burners were tested at intervals of ten degrees from horizontal to seventy degrees and it was found that in each case the light increased uniformly up to the latter angle. When the angle of seventy degrees was exceeded the mantle became visible through the hole in the bottom of the globe; the light not having to pass through the glass, the reading in each case is higher. The tests were made with coal gas, without admixture of any water gas.

Another form of inverted burner is shown in Fig. 17. This Messrs. Wright & Butler call the horizontal burner, and they claim for this burner that it cannot blacken fittings. It will be noticed that it can be used for either brackets or pendants. The products of combustion pass inside the coronet and so prevent any discoloring or tarnishing of the fittings.

The Star Inverted Incandescent Burner Company, London, was one of the first firms to introduce inverted burners. Fig. 18 shows the burner and mantle which is fixed with a bayonet attachment in such a manner that the burner can be fixed on a bracket or other fitting at any angle without fear of its falling off. Fig. 19 shows the same burner with bye-pass and pilot light. These burners can be used with or without globes. With a consumption of 2½ cubic feet a downward light of 70-candle-power is attained. Fig. 20 illustrates another form of inverted burner, mantle and shade designed for shop lighting, which are fitted up with flexible metal tubes and can be hooked back in much the same way as the electric glow lamp.

No. of tests.	Angle	Cubic ft. of gas per hour.	Pressure of gas intensities	Illuminating pwr. corrected to normal temperature and pressure.	Candles per ft. correct to normal temperature and pressure.
1	20°	3.55	15	76.56	21.56
2	70°	3.55	15	97.66	27.51
3	90°	3.55	15	122.76	34.58
4	70°	4.05	20	82.35	20.33
5	70°	4.05	20	97.58	24.09
6	90°	4.1	20	31.44	32.05

Illuminating power of gas.	Calorific power B. Th. U.
16.63	603.17

We did not intend to touch upon the inverted gas burner for street lighting, but cannot refrain from drawing attention to the adaptation of the Star inverted burner to street lanterns, Fig. 21. This has been done under the direction of Mr. W. R. Herring, M. Inst. C. E., Engineer of the Edinburgh and Leith Corporation Gas Undertaking, who made a series of most exhaustive tests of inverted gas burners before the Star burner was adopted. The consumption is 2½ cubic feet of gas per hour and a downward illumination of 70 candles. The following is a description of the principal parts of the burner as fitted in the ordinary street lamps in Edinburgh (see Fig. 21):

A. Special cock with bye-pass to flash light.
B. Burner.
C Flashlight.
D. Earthenware reflector.
E. Copper cone.

Mr. Herring in a report published in the *Gas Journal* at the request of the editor said: "We have, I believe, tested every make of burner now (April, 1906) on the market; and the following scale is the best possible illuminating power, at the consumption and pressure named that could be obtained. One word perhaps should be added with regard to these illuminating power tests, and that is to mention that the calorific power of our gas (Scotland) is greater than in England; averaging about 700 B. Th. U.

We thought these figures would be appreciated. All who know Mr. Herring admit that his tests are accurate and that he would not make so radical a change as the adoption of inverted gas burners for street lamps unless he had made quite sure that it was worth while and that the streets would be better lighted and cost less money to do it.

The last series of inverted burners that we shall draw attention to are those of the New Inverted Incandescent Gas Lamp Company, of Farringdon avenue, London. This company was one of the early ones in the field and their burners are in much demand. We illustrate, Figs. 22 and 23, their large burners. Of these they say 180 units of electricity with three 16-candle-power electric lamps give a light equal to 48 candles for 1,000 hours and with a current at 6d per unit would cost £4 10s. ($21.60). The large inverted burner, referred to will give 65 candle-power for the same number of hours at a cost of 9s. ($2.16), taking gas at 3s. (72c.)

ILLUMINATING POWER TESTS ON VARIOUS MAKES OF INVERTED BURNERS.
(EDINBURGH GAS)

Index to burner	Pressure tests	Consumption	Candle-Power	Candle-power per cubic foot.
A	23	2.30	59.5	25.87
B	20	2.71	64.0	23.61
C	20	2.97	70.0	23.52
D	15	2.84	74.0	26.05
E	15½	2.75	75.0	27.27
F	90	2.95	59.0	20.00
G	16	2.57	61.0	23.73
H	18	2.62	64.0	24.42
I	18	1.90	39.0	20.52
J	25	2.65	78.0	29.43
K	20	2.20	72.0	32.73
	25	2.47	81.0	32.79
L	21	2.76	62.0	22.82
M	20	3.45	76.0	22.03
N	27	2.40	34.0	14.16
	30	2.54	36.0	14.17

The names of the makers have not been divulged.

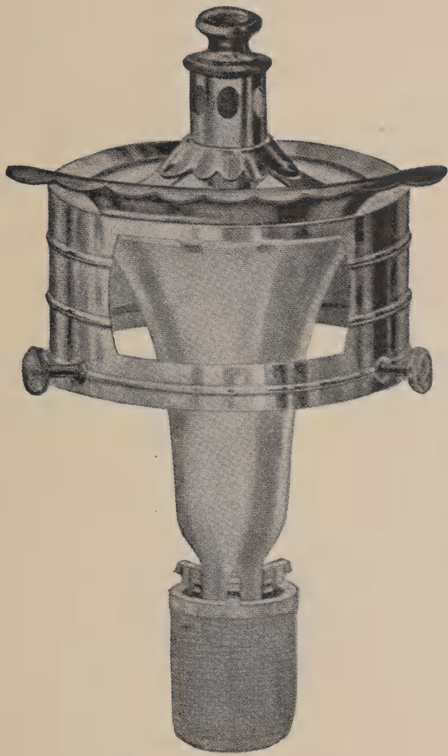


FIG. 22.—THE NEW INVERTED INCANDESCENT GAS LAMP CO., OF FARRINGDON AVE., LONDON, LARGE BURNER.

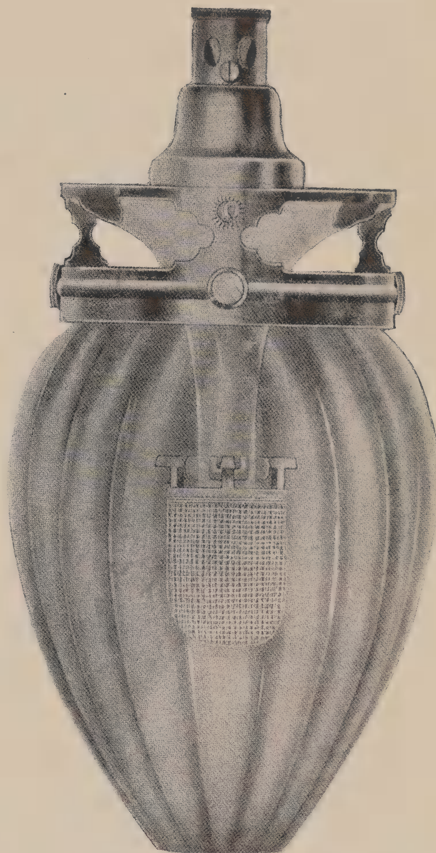
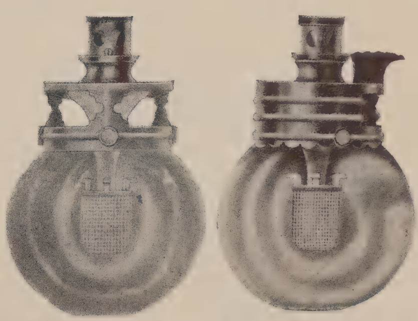


FIG. 23.—THE NEW INVERTED INCANDESCENT GAS LAMP CO., OF FARRINGDON AVE., LONDON, LARGE BURNER.

per 1,000 cubic feet. Figs. 24 and 25 are types of the Bijou burners. These lamps give 20 candle-power and the cost for 1,000 hours with gas at 3s. (72c.) per 1,000 cubic feet would be something less than 3s.

These lamps are, we believe, being manufactured under American patents by the Ramsdell Inverted Gas Lamp Company, and it will, we are sure, be of interest to readers to know that on this side the business is under the direction of several leading gas engineers, that the output is very large, and that the company's productions are most highly thought of.

We will append a table showing a series of tests carried out by Mr. James Foreman, a photometrician of standing in England, whose name we have already brought under the notice of readers of THE ILLUMINATING ENGINEER.



FIGS. 24 AND 25.—TYPES OF THE BIJOU BURNERS.

NEW INVERTED GAS BURNERS.

Description	New Inverted Bijou Burner (Porcelain deflector with globe)	New Inverted Burner Porcelain Deflector with globe.
Barometer	30 inches	30 inches
Thermometer	58° Fahr.	58° Fahr.
Quality 16 candle-flame	16.3 candles	16.3 candles
Calorific power (gross)	620 B. Th. U.	620 B. Th. U.
Pressure in inches of Water	2.3 inches	2.4 inches
Gas Consumption in cubic feet per hour (1.2ft)	1.2 feet	3.2 feet
Candle-power horizontal	16.60	52.73
10°s	18.83	50.50
20°s	19.34	53.46
30°s	19.63	58.50
40°s	18.88	53.45
50°s	19.31	52.04
60°s	18.33	56.78
70°s	19.29	52.39
80°s	22.73	57.13
90°s	22.00	51.25
Candle-power, mean hemispherical	19.104	54.032
Candles per cubic foot	15.920	16.880
Cost of gas per 1000 hours at 2s. 6 d. per 1000 c ft. (60c.)	1.88 d.	1.77 d.

At the moment of writing we have received the current number of the *Gas Journal,* which reports that a revised and extended text of the lecture by Professor Drehschmidt has been published in the *Journal fur Gasbeleuchtung,* and gives an abstract translation of the same. Space will not permit any lengthy reference, but the following table read in conjunction with the figures given in the early part of this article will bring the subject more closely up to the rapid improvements that have been made.

The review of inverted incandescent gas burners is by no means exhausted. The patent record gives a very positive proof of many new methods being put on the market to court the public favor.

ILLUMINATING POWER OF INCANDESCENT BURNERS.

Description of tests.	Upright Burner without Reflector	Inverted burners: Clear globes "M" (best in 1905)	Inverted burners: Clear globes "G" (best in 1906)	Inverted burners: Opal globe "G" (Best in 1906)
Consumption per hour cubic feet	4.42	3.42	3.18	3.18
Horizontal illuminating power candles	78.9	78.9	95.0	74.0
Mean illuminating power spherical	59.8	68.9	76.8	50.2
Lower hemispherical	54.6	90.4	101.5	56.1
Mean illuminating power spherical per cent of horizontal	75.8	87.3	81.0	67.7
Mean illuminating power, lower hemispherical per cent of horizontal	69.1	114.4	106.9	75.8
Candles per cubic foot per hour consumed				
For mean spherical illuminating power	13.54	17.60	24.16	15.80
For mean lower hemispherical illuminating power	12.36	23.08	31.94	17.65

The gas pressure was in all cases 40 mm = 16.

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THE RELATION OF ILLUMINATING ENGINEERING TO COST OF LABOR

The treatment of illumination as an engineering problem, and the establishment of illuminating engineering as a distinct profession, is undoubtedly due in a large measure to the enormous waste in the prevailing methods of lighting. So wasteful have been the methods in common use that they have attracted the attention of those entirely unskilled in the production of light, as well as those who have assumed the responsibility of the installation and use of such lights. For this reason it is quite natural and legitimate that the illuminating engineer should urge the greater economy in the production and use of light as one of the chief reasons for the employment of his services. The prospect of reducing lighting bills is undoubtedly one of the most attractive arguments that can be advanced to the layman to induce him to consider the employment of an illuminating engineer; with the attendant fees and possible expense of changes in installation. The comparatively few cases in which large installations have been either designed or remodeled on engineering lines amply justify this claim for economy. In all cases where economy has been the object sought, the saving effected has exceeded expectations.

The mere saving of a certain percentage of the total cost of light production, however, is by no means the chief object in illuminating engineering. The cost of lighting in any case is but a small fraction of the total "fixed charges" of which it forms a part; and this is true as well for the small installation of the private house, as with the largest plants.

Artificial illumination is one of the first and most important utilities of modern civilization; and the first object sought, and to which all other considerations must be subsidiary, is the production of such an illumination as will most fully satisfy the conditions under which it is to be used; and this is equally true of the smallest and largest lighting systems. For example, in the case of a single lamp to be used for reading, the question of first importance is to obtain such an illumination as will permit reading with the greatest possible degree of comfort, and any variation from this aim for purposes of economy is a complete perversion of the fundamental principles of engineering. Similarly, in the lighting equipment of a counting-room or factory; if the illumination does not enable the accountants or operators to produce results as nearly as possible equal to those which they are capable of producing under good daylight conditions, the system must be considered a failure, no matter how cheaply maintained.

It is a well-known fact that the cost of labor makes up by far the greatest proportion of the total cost of all finished products. This, of course, includes the cost of non-productive labor, such as accounting, selling, etc. Compared with the labor cost in any given article, the cost of the illumination necessary in its production is a mere trifle. If one will stop to do a little figuring, it will be seen that the

loss in efficiency of the workman by poor illumination represents a far greater loss than even the most wasteful methods of producing and utilizing the light. Take as a simple illustration the case of a workman receiving 50 cents per hour, which will probably come somewhere near the average for skilled labor at the present time. At 10 cents per k.w.h. for electric current, which may be taken as a maximum in cases of large installations the ordinary 16-candle-power lamp costs about one-half of a cent an hour, or 1 per cent of the cost of the workman's time. The cost of such a lamp for a day of ten hours, would, therefore, amount to 5 cents, or the workman's wages for six minutes; in other words, if the workman lost six minutes' time on account of poor illumination, it would equal the cost of a lamp, sufficient in most cases for all the special light he would require for an entire day of ten hours. In cases where the current is generated in connection with the general power plant, and represents little more than the actual cost of fuel, these figures would be reduced to one-fifth the amount given. In other words, a skilled workman would have to loose only about one minute of his time during a day of ten hours to equal the cost of a 16-candle-power lamp for the same period.

If an exact computation were possible of the loss represented in both the quantity and quality of the output of labor due to improper or insufficient illumination, the grand total would put in the shade the most extravagant estimates of loss due to wasteful methods of production and distribution of light. In urging the claim of illuminating engineering this important and indisputable fact should not be lost sight of.

THE COMMERCIAL RATING OF ARC LAMPS

The unscientific, misleading, and wholly illogical methods of commercially rating light-sources has been brought into special prominence recently by the case of the city of Colorado Springs against the company which has been supplying the electric lights to the city.

In 1898 the city granted a franchise, under which the grantee was required to supply "standard 2,000-candle-power arc lights" for lighting the city streets, at a certain specified amount per month. At that time the familiar 9.6-ampere d. c. open arc lamp was in general use. Subsequently, a contract was made with another company for the lighting of the streets. This company, after making a demonstration in one of the streets, substituted the 6.6-ampere a. c. inclosed arc lamp throughout the city. This change was made without any formal action on the part of the City Council, and was accepted without question for several years. Finally, a company operating under the original franchise assumed control of the street lighting, and continued the use of the same lamps.

After about sixteen months' operation the city authorities discovered, by some means, that the arc lamps in the streets were "not giving 2,000-candle-power," and a claim was immediately put into the company for rebates during the time that the new form of lamp had been in use, and refused to pay any bills for lighting thenceforth.

In order to settle the dispute, the matter was recently submitted to a board of arbitration, for which there is a special provision in the laws of Colorado, and the case was heard during the first part of the present month. This hearing was noteworthy in several respects. It is probably the first time that the question as to what lamp of the alternating inclosed type may be considered, from the illuminating point of view, as equivalent to the old open arc, d. c. type; and in trying to arrive at a legal adjudication of this question, the whole subject of the rating and photometry arc lamps received probably a more

complete thrashing out by the best known experts in this country than has ever taken place on any single occasion before. Dr. Louis Bell, Mr. Louis B. Marks, Prof. C. P. Matthews, Prof. J. C. Shedd, and Mr. Alton B. Adams appeared as experts for the city; and Mr. W. D'A. Ryan and Mr. R. F. Schuschardt for the Company. The hearing consumed six days, nearly all of the time being taken up with testimony of the experts on technical matters. A considerable amount of this testimony will doubtless be of interest to our readers, and abstracts will be given in our next issue.

The fact that such a dispute could arise leads at once to a consideration of the cause. The wording of the original franchise, "standard 2,000-candle-power arc lights," was undoubtedly considered a perfectly definite and unambiguous statement at the time it was made—1898. In the light of present knowledge and conditions, however, it will at once be seen how readily conflicting opinions as to its meaning might arise.

First, as to the meaning of "Standard 2,000-candle-power":— It was admitted at once by all the experts that the term "2,000-candle-power" must be taken in a purely Pickwickian sense, and by no means represented the actual measurement of the candle-power of any practical arc lamp for street lighting purposes that had ever been made up to that time. It was likewise agreed that a 9.6-ampere d. c. open arc lamp fulfilled the conditions of the specification at the time the franchise was granted; but the franchise is to run for twenty-five years, and so rapid is the practice of illumination changing that the particular lamp which the parties had in view is already nearly obsolete. As neither law nor justice would require the owners of the franchise to maintain an obsolete or discarded form of lamp when better types are available, the very pertinent question arises, what at the present day is a standard 2,000-candle-power arc light? In recent contracts for street lighting this troublesome question has been generally eliminated by omitting any mention of candle-power, and specifying the exact type of lamp instead; but it is hardly supposable that the present instance is the only one in which a contract calling for a standard 2,000-candle-power arc light is in force, having still some years to run. The parties to such contracts will, therefore, naturally be curious to know what the term means at the present time.

It is also worth noting that the term "arc light" appears instead of "arc lamp," which was evidently the thing that the contracting parties had in mind. The word light is very often metaphorically used to signify the lamp, or apparatus which produces the light. While such a use is perfectly permissible in colloquial language, it is out of place in technical or legal documents, in which absolute exactness should be aimed at. Obvious as the meaning seems to be in this particular case, it has, nevertheless, furnished grounds for additional discussion.

This hearing will perhaps also be memorable as being the first time in history that the profession of illuminating engineering has been officially recognized. In qualifying as an expert, Mr. Marks gave his profession as an illuminating engineer.

THE TROUBLES OF THE CONSULTING ILLUMINATING ENGINEER

While illuminating engineering has been recognized by the scientific world, and at least in one instance is a matter of official record, the illuminating engineer is either wholly unknown, or a very dubious individual, to the general public, to which he must look for employment. Prejudice and custom are the last rocks to be submerged in the general tide of progress. "What has been should continue to be," is the principle upon which the great majority of human

action is based. Deviations from this maxim are the exception, and take place only with a certain class of minds, and then only after a considerable degree of consideration.

It is also a curious, but well-established fact, that it requires more persuasion to induce an individual to improve his condition than it does to lead him into ways that will result in retrogression. The greater the improvement, generally speaking, the stronger the opposition which it meets in the beginning. This has been the universal history of all progress in science, religion and ethics. In offering his services for the benefit of his clients the illuminating engineer, therefore, must not consider himself especially singled out by an unfeeling and unappreciative public, if he received rebuffs and contempt. A straight-forward proposition to a business man, assuring him a continuous economy with improved service in one of the most important and necessary utilities, would naturally be supposed to receive prompt acceptance, or at least be given a careful investigation. Such a supposition, however, is based only upon logical reasoning; and in his actions man is an exceedingly illogical creature.

Even ocular and practical demonstration is not always sufficient to overcome opinions that have been long held as a matter of habit. For centuries it was accepted as a fact that bodies fell in proportion to their weight, i. e., a two-pound weight would fall a given distance in half the time required for a pound weight. Gallileo is said to have disproved this by a simple experiment of dropping different sized weights from the top of the famous leaning tower in Pisa; and it is related that, on being both ridiculed and reproached for announcing the fact that all bodies fall with the same velocity, he called his accusers to witness the experiment for themselves. The results came out precisely as he had stated; but the spectators, including the professors in the University, went away wholly unconvinced, and afterward made Gallileo's life so much of a burden on account of his dangerous habit of discovery, that he was obliged to give up his own professorship in the University, and seek employment elsewhere. Incredible as this historical fact may seem, we know of recent cases in the field of illuminating engineering which are not one whit less absurd. A single example may be interesting.

A certain large and well-known store in this city some years ago found, on account of a general call for more light, that its generating plant was being pushed far beyond the reasonable limits of its capacity. After much persuasion, coupled with a strong personal "pull," the proprietors were induced to permit the alteration of one floor in accordance with the specifications of an illuminating engineer, on the express understanding that they were to assume no cost or responsibility for making the changes. The changes were duly carried out, and an ample illumination, admitted to be much preferable to the former one, was produced with half the consumption of current. Now, it would seem a fairly reasonable conclusion that, as a matter of business, the remaining floors would have been similarly remodeled; the total expense of which would have amounted to less than $5,000. Such, however, was not the case. The proprietors eventually installed an entirely new generating plant of double the capacity, at a cost of some $30,000.

Probably the most frequent reply which the illuminating engineer receives on presenting his case to the prospective client, is, that "the electrical engineer looks after all that," or possibly, "I leave that to my architect." We can imagine the student who had made a special study of anatomy and surgery presenting his professional card to a prospective patient some three or four centuries ago, and having it politely returned to him with the remark, "I see no need for employing your special talents; my

barber looks after all those matters." As a matter of fact, it is not many centuries since one who had successfully cut off superflous locks of hair and beard was considered perfectly competent to prune the human frame generally; and less than a century ago a text-book on "Natural Philosophy" included a full treatment of astronomy, physiology, and the various branches which are generally classed as natural history and biology. But specialization has continued at a constantly increasing rate; and the client who will refer the illuminating engineer to his architect, or electrical engineer, with the calm assurance that they "understand all about the subject," would consider it a serious reflection on his intelligence if he were advised to consult a physician of general practise for a severe affliction of the eyes, for example.

Electrical engineers are also somewhat inclined to take the same view of the universality of their calling and talents. This results partly from a feeling that to admit ignorance on any allied subject may reflect on their professional standing; and partly from a fear of competition in their special line. Both of these reasons are absolutely without foundation. The electrical engineer need consider it no more of a reflection on his ability to frankly admit that he is not an illuminating engineer, than he would to decline a request to act in the capacity of a mechanical engineer. As to the illuminating engineer encroaching on his domain, he is simply assuming unnecessary and uncalled for responsibility when he argues against illuminating engineering as a specialty. The illuminating engineer would certainly not assume either the labor or responsibility which must devolve upon the electrical engineer, and so could not in any case be a competitor. The two branches of engineering are related, and the two engineers should work in harmony, to their own mutual advantage, as well as to the advantage of their common client.

It has been said that the best way to insure the repeal of a bad law is to enforce it; and perhaps it would be the surest way to convince the architect or electrical engineer that illuminating engineering is a study requiring a highly specialized knowledge, which in the regular order of things, the electrical engineer and architect do not possess, to hold them strictly responsible for the results obtained, as compared with the results secured by illuminating engineers. If the actual blunders made in this way were sure of being brought out, the path of the illuminating engineer would be made smooth indeed.

WHAT IS AN ILLUMINOMETER?

In the hearing of the Colorado Springs case, one of the experts testified, on cross-examination, that he had never heard of an "illuminometer," and did not know what such an instrument was. It would be interesting to know whether his ignorance applied only to the word, or to the instrument which that word signifies. Has the word illuminometer a rational reason for existence? The science of illuminating engineering is a new one; in fact, its own title has only become firmly established within the past year, and like any new department of science, it will naturally give rise to new technical terms, which will become a recognized part of the English language if they express some permanent idea. Although the term illuminometer is perhaps still struggling for existence, we believe that it fills an actual need. An illuminometer is an instrument especially designed for measuring intensity of illumination; and while it may rest on the same foundation principle as a photometer, the thing which it measures, and the units in which the values of such measurement are expressed, are certainly quite different from the quantity measured by the ordinary photometer, and the sooner this distinction is understood, the better for illuminating engineering.

Correspondence

FROM OUR LONDON CORRESPONDENT

The use of high power lamps for advertising purposes and for lighting shop windows, in our large cities, is becoming something of a nuisance, and the Court of Common Council of the City of London are taking steps to place some definite limit upon the area that a shopkeeper shall be at liberty to illuminate. There have for some time past been regulations as to the height from the ground and the projection beyond the line of frontage, both most important factors effecting the public. The Courts have now extended their rules and provide that the external dimensions of lamps shall not exceed 2 feet 3 inches in any direction, and that lamps shall not be fitted with high power lights, unless screened in such manner as to prevent the rays of light falling upon the public way.

Perhaps the greatest offenders in this excessive illumination are the cheap tailors who outwit one another in the matter of lighting their premises, and certainly the most objectionable lamps are the electric flame arcs. These, when fixed at less than seven feet from the pavement, are really appalling and blinding; it is indeed time that this waste of illumination and cause of irritation to the public should cease. The authorities have taken a wise step in insisting that the storekeeper shall at least confine his outrageous illumination to his own shop windows, and not be allowed to inconvenience passers-by.

Acetylene gas is slowly being adopted for illumination purposes in Great Britain, several small towns, particularly in Scotland and Ireland having put down complete plants, and very many isolated Institutions, Schools, Country Mansions, and Churches are lighted with acetylene gas. In Germany the gas has been much more generally adopted, and experiments of an exhaustive character are being made in connection with the employment of acetylene gas for railway carriage illumination. The efforts made to adapt the incandescent burner to the gas have so far not met with much success, as it has been found that the ordinary run of mantles will not withstand the vibration of the German trains for any length of time. Herr Kuchel, of Vienna, has tried supporting the mantle by means of a ring at its base; this ring is affixed to the burner with a bayonet joint and the mantle is closed in at the top, very much the same as the inverted mantle. The inventor claims for burners fitted with these mantles that the combustion of the acetylene gas is quite perfect, that the burner will work satisfactorily at a pressure of 46 m.m. (1.81 inch) of water column, that the mantles will stand severe vibration, and that the light developed equals 1. Hefner Unit, per 0.20 to 0.22 litre equivalent to an illumination of from 120 to 130 candle-power per cubic foot of gas.

At present these are difficulties in regard to the use of inverted incandescent burners with acetylene gas; the principle difficulty appears to be in the polymerisation of the acetylene, which takes place as it descends through the hot mixing tube of the burner. It appears to us therefore that the tube of the burner should be specially protected from the heat of the flame in order to avoid the action described.

Intensified gas lighting with acetylene has not, so far as we are aware, been attempted either in Great Britain, or elsewhere. Herr Kuchel has however, we understand, succeeded in constructing intensified incandescent acetylene lighting units possessing illuminating powers up to, if not exceeding, 1,000 candles; but such burners are not available where acetylene gas

is obtained from either a public supply or private generator. Further economies in consumption must therefore be sought in burning the gas with the aid of oxygen instead of air, and so causing the atmosphere flame to play upon some suitable refractory material, such for instance as the soft or hard "limes" used in the projection lantern with oxy-hydrogen gas. These few lines have been prompted by a review of a paper read by Herr Kuchel which appeared in *Acetylene,* an excellent journal devoted to the subject. The reviewer concluded his article by saying that:—"A flame of acetylene fed with oxygen is hotter than a flame of acetylene fed with air, because in the former there is no nitrogen present to waste heat and enlarge the flame; the hotter flame is capable of affording more light, in accordance with the law that the luminosity increases in proportion to the fifth power of the absolute temperature. When the point of the inner region of an oxy-acetylene blowpipe flame is made to impinge upon a body coated with thoria, bringing it to incandescence, a very white light is evolved, and the illuminating power, with a very small consumption of acetylene gas in place of hydrogen gas, may be as much as 500 candles. This illumination can of course be increased enormously if the rays are brought into parallelism by means of lenses, the beam of light having an intensity of 80,000 candle-power. The possibilities of acetylene for high power illumination have by no means been exhausted."

Periodically the daily papers in London publish articles, intelligent and otherwise, upon electric and gas lighting. The *Times* quite recently devoted much space in dealing with the "Strength of the Gas Industry." The writer very truly says:—"Gas companies have been spurred on by the incessant pushing of electricity for lighting and power purposes; this has compelled them to cheapen the supply, and this in its turn has cheapened the production." He overlooks two technical gains which recent legislation has given to the supplier; the first is the consent of Parliament to the sale of gas of lower candle-power, and the second, the repeal of the clauses controlling the removal of sulphur impurities. Reduction of candle-power has been brought about through the almost universal introduction of the incandescent burner, which does not need a gas of high illuminating power, so that the cost of enrichment by cannel high grade coals, benzol, or other enrichers, can be dispensed with. The second gain has reduced the cost of purification considerably. The consumer does not suffer by these economies, unless he be foolish enough to insist upon using flat flame burners, —in which case the time may come when he will be obliged to take a tallow candle to look for the gas flame.

The question of the "Relative Cost of Gas and Electricity," are like the poor, "always with us," it is therefore rather satisfactory to us to quote the figures appearing in a disaffected paper, which certainly cannot be charged with bias for either illuminant. The writer says: "In instituting a comparison the question of economy is the main, and in by far the majority of cases is the only factor in settling any doubts as to the merits of the two competitors." The table below gives the comparative cost of both gas and electricity.

The figures for street lighting are

	Price per Unit	Work obtained from one penny	Price 1000 cubic ft.	Work obtained from one penny
Street Lighting...............		425 Candle hours		740 candle hours
Domestic "	4 d.	72 " "	2s. 6d	572 " "
Heating....................	1 d.	17 pints of water boiled	2s. 6d.	44 pints of water boiled
Power......................	1 d.	1⅓ horse power per hour	2s. od.	2½ horse power per hour

taken from tenders submitted by the Metropolitan and Charing Cross Electric Light Companies, and the Gas Light and Coke Company, for the lighting of Kingsway and Aldwych, Both of these tenders have been mentioned by us, and attention drawn to the very effective illumination of the thoroughfares named. The writer of the article continuing says: "The table illustrates in a most conclusive manner that, in regard to cheapness, electricity is at present very far behind, so much so that not only is gas now adopted in nearlv every case in which the two rivals meet in open competition, but it has displaced in many cases existing electric lamps. One Gas Company reports that they have displaced entirely electricity in nearly a thousand cases during the past two or three years, and that in more than a thousand other cases electricity has been largely superseded by gas.

It will be interesting to note side by side the position of Gas and Electrical Companies stocks' sales, as officially quoted on the London Stock Exchange; a glance at the following table will show the relative values.

Electricity Companies	Highest Price 1903	Price end of 1906	FALL
Charing Cross..........	$9\frac{7}{8}$	4	$5\frac{7}{8}$
City of London........	12	10	2
County of London......	$9\frac{5}{8}$	$8\frac{1}{2}$	$1\frac{1}{8}$
Edmundson's..........	$7\frac{1}{16}$	3	$4\frac{1}{16}$
Metropolitan..........	10	8	2
St. James Pall Mall	$16\frac{1}{4}$	10	$6\frac{1}{4}$
Westminster...........	$13\frac{3}{4}$	10	$3\frac{3}{4}$
Gas Companies	**Highest Price 1903**	**Price end of 1906**	**RISE**
Brentford.............	245	$267\frac{1}{2}$	$17\frac{1}{2}$
Brightland Hove.......	215	$232\frac{1}{2}$	$17\frac{1}{2}$
British Gas Light......	$40\frac{1}{2}$	$41\frac{1}{2}$	1
Commercial...........	110	$111\frac{1}{2}$	$1\frac{1}{2}$
Gas Light & Coke......	$90\frac{1}{2}$	99	$8\frac{1}{2}$
South Metropolitan	127	129	2
South Suburban.......	$117\frac{1}{2}$	$124\frac{1}{2}$	7

These figures speak for themselves; four of the Electricity companies have reduced their dividends during the period mentioned, whilst on the other hand, four of the Gas companies are paying increased dividends. These latter undertakings are working under strict Parliament enactments, which control quality, price, and dividends, whereas at present the electricity companies are comparatively free lances.

For ourselves we believe that the present wave of unpopularity of the electric light is due to the enormous number of inferior glow lamps which have been dumped into this country from Europe, the principal offender being Germany, the lamps have a very short efficient life, and we question whether at their best they could stand photometric tests for the candle-power at which they are rated. The filaments soon char, the light dims, more current is needed, and after a very short existence the filament snaps and life is ended. Another reason is the faulty glass globes which are often so thin that they will hardly stand gentle handling. But we believe there is still another cause for unpopularity, and that is the excessive and unnecessary brilliance of arc and flame-arc lamps, which cast a deep black shadow of any object that obstructs their effulgent rays. For street lighting these lamps are placed much too high, and at least 40 to 50 per cent of their brilliancy illuminates upper rooms of the adjacent buildings and the sky.

The public require moderate illumination, and when it is possible to obtain from 2½ cubic feet of very average coal gas (of say 14 to 15 candle-power), an illumination equal to 70 candles and upwards, with the inverted incandescent burner, costing complete, with ceiling plate, flexible metal drop pipe, burner, mantle and glassware, anything between 10s and 20s ($2.40 and $4.80), can it be wondered that gas, as an illuminant, is reaching the high water mark of popularity?

As marking the advance in gas lighting and the enormous improvement in methods of burning gas we give an illustration, taken from the *Co-Partnership Journal,* issued by the staff of the South Metropolitan Gas Company, which is very conclusive as to the work of the past twenty years.

It would be amusing if it were not

sad to note the dodges the foreigner adopts to get his goods on the British market. At the present time and for several years past, the German manufacturer has supplied factors in this country with gas fittings, burners, lamps, and glass goods for the same, in enormous quantities. Some of these are good, some bad, and some very bad. The worst feature of the burners is that the identical article is sold to several factors who adopt it "and call it after their own name," or attach some fancy name to it for their own purposes. Quite recently one of the leading technical journals published rather a lengthy illustrated description of the "Graetzin" lamp, made in Berlin. In the next issue it was explained that this lamp had been sold by certain houses under other names, three instances being given, viz: "Nero," "Vesta," and "Viaduct," the lamp being also sold under the makers name for it (Graetzin). We know that in many trades this special naming of foreign made articles is rampant, but it leads to much confusion. The factors here too often claim that these articles are their own manufacture, and so deceive the public and do much harm to British manufacture. If the foreigner enters into competition with us it should be made perfectly clear to the public that whether we trade direct with them or through a factor that the goods manufactured by him should have both his name and address stamped upon each article. We do not exonerate the factors, or middle men, they are as responsible and even more to blame than the manufacturer, in the course they take to deceive the public. The larger firms who carry on this class of business here have originated with men who sold on commission, holding stock at the risk of the foreigner; these firms have waxed rich and are able to put pressure upon the manufacturer and to cheapen goods, especially metal goods, by reducing weight, and so buy at the lowest possible price. Now that metals are rising in price they are the first to circularise their customers of advances in price and reductions in discounts off wholesale lists. Business in gas fittings is in a very unsatisfactory state, but the constant cry for cheap goods is undermining the trade, and fittings are sold of so flimsy a nature as to make them quite unfit for the rough handling they must receive. On the other hand good fittings can be obtained, and as these are now so simple in design, carrying either an upright or an inverted incandescent burner, the installation of good class fittings in a house is not the costly matter it used to be in the days of five and ten-light chandeliers.

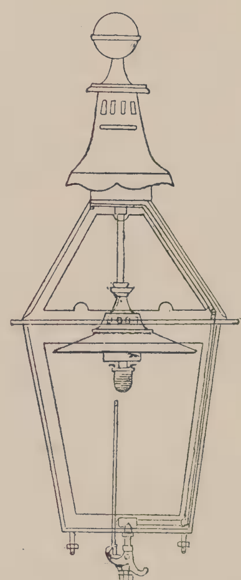


FIG. 1.—INVERTED GAS BURNER ADAPTED TO STREET LANTERN

In Solihull, one of the suburbs of the busy city of Birmingham, experiments have been made with street lighting by means of inverted incandescent gas burners. The burner used is known as the Etna, and is manufactured by a Birmingham firm. The experiments have covered a period of two years, so that the conclusions arrived at are of considerable value to those who are interested in street illumination. The average consump-

tion of each burner is three cubic feet per hour at a pressure of 20-tenths and the illuminating power averages about 65 candles. The burners are fitted into the ordinary 14-inch street lanterns (see illustration) under a 10-inch opal reflecting shade, and a small glass bulb is fitted on the burner for the protection of the mantle. The supply pipe is carried from the bottom and up inside the coner of the lantern, the burner being suspended from stretching piece fixed across the top, as shown; the bye-pass is carried up vertically from the stand pipe. The conversion of the lighting from flat-flame to inverted incandescent burners can readily be effected, and at comparatively small cost. We believe that the substitution of burner and fittings, as a fact, cost less than 10s ($2.40) per lamp; the consumption of gas is much less, and quite three times the amount of illumination is obtained. The life of the mantles has averaged about forty days. The use of the opal shade increases the downward hemispherical lighting area, and we understand that the particular burner gives sufficient light to enable the small print of a newspaper to be read at a distance of 15 yards from either side of the lamp. These particulars were included in a paper read by Mr. R. I. Rogers, before the Midland Junior Gas Association.

CHAS. W. HASTINGS.
Editor *Gas Engineers' Magazine.*

FROM OUR READERS

Editor, THE ILLUMINATING ENGINEER, 12 West Fortieth Street, New York City.

DEAR SIR—I have read with much interest the article in the January number on the lighting of two modern Churches. I have no information on this subject except that which is given in the article but I noticed that you state "on either side of the reader's desk on the corners of the rostrum are placed handsome bronze standards supporting concentric globes for frosted lamps." It is evident therefore, that the entire audience as they sit facing the speaker, must have these lights directly in the field of vision and no matter how well they are frosted, or even enclosed in large diffusing globes the effect must be at least uncomfortable to the eye.

In an editorial on Direct vs. Indirect Illumination, you call attention to the fact that even when lights are out of the field of vision so that one is not looking at them, nevertheless they strike the ball of the eye; the effect is very trying.

The case mentioned of the Christian Science Church in Boston is an aggravated case of this. I simply call your attention to this matter inasmuch as you state that the lighting of the Church is practically perfect and the fault mentioned follows one of the primary principles of illumination, namely, to get lights out of the field of vision.

V. R. Lansingh.
New York, Feb. 2, 1907.

Editor ILLUMINATING ENGINEER:

DEAR SIR.—I beg leave to invite attention to some errors in your text.

The electric plant was installed on board the Trenton by Commander (now Rear Admiral) R. B. Bradford. My work, on board the U. S. Fish Commission Steamer Albatross preceded that on board the Trenton. I did wire the White House, State, War and Navy Building, the Government Hospital for Insane, and installed plants therein in the early days.

REAR ADM. GEO. M. BAIRD.
1505 Rhode Island Avenue,
Washington, D. C.

The Illuminating Engineering Society

MEETING OF THE NEW YORK SECTION, FEBRUARY 8th.

PHOTOMETRY OF INCANDESCENT GAS LAMPS

By Thos. J. Litle, Jr.

PHOTOMETER ROOM EQUIPMENT.

In equipping a photometer room for gas testing, careful attention must be given to the lay-out of the piping; the pipes should be of ample carrying capacity, should be exposed, and should be run in as direct a manner as possible so as to be at all times easily accessible. In making turns Ls should never be used, but plug Ts should be substituted as it is very frequently necessary to tap in on the various lines on some special test. Each run should be carefully tagged. The fittings used should be of large bore so as to avoid any impedance in the gas flow, otherwise termed "wire drawing." A plan should be kept of all the piping in the room on which the various runs should be designated.

A good solidly built gasometer, having a capacity of at least fifteen cubic feet, is indispensable. The bell should be carefully counter-balanced with regular as well as compensating weights, to take care of varying displacement during its descent, and some convenient method should be arranged on the top of the bell for quickly weighting it down for different desired pressures. The method generally used is that of simply placing loose weights on top of the bell, but this is awkward, particularly if one of the weights slips down in the water seal and has to be fished out before proceeding with the test. A holder of at least this size I consider necessary, because if a small holder is used a test must be interrupted frequently to refill the holder. Again it is desirable that a test be completed with the same gas as that with which it was started. It is frequently found that during the day the quality of the gas may change a trifle. The change in conditions so introduced for all purposes of commercial work would be considered negligible, but for accurate testing would create an error whose extent it would be difficult to determine.

At least two accurately calibrated wet meters should be available; a small one for ordinary small burner work, requiring a consumption of from three to seven feet per hour, and a large one for use with cluster burners, such as gas-arc lamps, intensified lamps, etc.

I prefer to use a stop-watch in place of the stop-clock attachment which is frequently incorporated as a part of the meter.

The photometer room should be equipped with a five-foot meter-prover, and the meters should be proved from time to time on a pressure at which they are generally used, which is ordinarily two inches.

Inserted in the line between the meter and the lamp to be measured should be a pair of flexible diaphragm pressure controllers. There should be also a U water gauge attached in the line as close as possible to the outlet on which the light to be measured is placed.

If two different gas supplies are available in the photometer room, great care must be taken that these are not inadvertently mixed through the piping in the room, and to prevent this either a three-way cock should be used or a pair of cocks connected so that when one is open the other is closed.

As condensation may collect in the various pipes in the room it is necessary that they all be inclined in one general direction, so that each can

be dripped and occasionally washed out. I consider this very important, for on a warm day I have seen cases where phenomenally high candle-powers were recorded, when as a matter of fact nothing but ordinary gas was passing through pipes filled with condensation, which in turn was taken up by the warm gas. In this particular case the gas used was rated at 18-candle-power, but it gave 30-candle-power, much to the astonishment of the engineer making the test.

Any good horizontal bar photometer may be employed, but it should not be less than 100 inches in length, as on a short bar a slight movement of the sight box in either direction represents a considerable difference in the reading and multiplies the error. I prefer a metallic bar, which when mounted on a heavy plank table shall bring the sight box on a level with the eyes of the operator when in a standing position. The table will be found extremely useful for grouping the meters, pressure controllers, water gauges, etc.

The lamp to be measured should be attached to an outlet which may be raised or lowered to any desired point, or swung through any desired arc, in which case the gas connection should be through telescopic tubes contained in the riser, sealed with mercury; it should also be equipped with some clamping device to avoid shifting during the test. A plumb bob should be suspended from a point immediately below the burner connection and the table should contain a brass plate, cross scored, over which the bob should center. I prefer to use a series of screens along the bar with apertures just large enough to admit the light to be measured. The standard may be electric only if a complete equipment of testing instruments, storage batteries, master standards, standards and sub-standards is available. For quick and satisfactory results the Pentane standard, of the Harcourt type, has proved very satisfactory; it is simple and transportable. Pentane of proper specific gravity may now be obtained readily, and the lamp in its present form is perfectly safe.

For a radial photometer I prefer a modification of the Dibdin, which is a direct reading apparatus and one in which the reading screen is so adjusted as to always divide the angle between the standard and the light to be measured. With this photometer the light to be measured is suspended from a horizontal bar which slides between a pair of uprights. A radius rod connects to the sight box which is mounted upon a table, which in turn travels on a track on the floor. A protractor is mounted on the table in order that the angle described by the radius rod may be ascertained. The standard is mounted on a carriage which runs along the track on the table and may be either electric or an argand gas standard. If an argand standard is used great care must be taken to see that the gas pressure is uniform. The gas during the entire test should be taken from the gasometer. For measuring lights of high units a Welsbach mantle may be used as a standard. One that has been thoroughly seasoned by burning for a long period is preferable, and the same precautions should be taken as to gas conditions as would be taken with the argand standard.

Gas connection with the light to be measured is obtained by connecting through a rubber tube the outlet on the horizontal bar to the outlet on the side of the wall.

With this photometer radial readings can be made through 180 degrees in a vertical plane and by shifting the burner 180 degrees in the horizontal plane, 360 degree readings may be taken. The apparatus to which I refer is not at all complicated, as might appear.

A gas testing laboratory should also be equipped with a good calorimeter for determining the heating value of the gas. The most satisfactory calorimeter for this purpose I find is the Junker. In addition to the calorimeter, there should also be nec-

essary apparatus for making complete gas analyses, as to determine the value of the appliance we must know the exact conditions under which the appliance is being tested. One should also be able to get conditions which would represent those which would be encountered when the appliance is in actual service. We know, for instance, that some appliances will work admirably on water gas, but give very unsatisfactory results on coal gas, which might in one case be attributed simply to a difference in specific gravity, in which event it would, of course, be seen that a gravity apparatus in the laboratory would be indispensable.

A good barometer and hygrometer are also necessary. Considerable attention should be paid to ventilation in the room, at the same time avoiding draughts. For this purpose a very high ceiling is desirable.

Running water in the room is very necessary, particularly a hose connection for renewing the water seal in the gasometer, as it is quite necessary to replace the water occasionally on account of evaporation. Also considerable condensation may at times collect on the surface of the water and may be absorbed by it, in which case the water gives off a very objectionable odor, and, as well, slightly affects the quality of the gas in the gasometer.

For measuring high pressure, a very long U tube water gauge is necessary, but where this may not be found adequate, mercury may be substituted for the water in the gauge.

I have gone into the equipment of a gas photometer room at length, as all of the above equipment will be found necessary. There are, of course, a great many other accessories than those I have mentioned, such as electric igniters for the light to be measured, a small electric lamp for reading the scale on the photometer bar, etc.

Dust-proof closets should be in the room for carrying a stock of mantles, burners, gauzes, Bunsen tubes, glassware, etc.

TESTING THE MANTLE.

A specially designed mantle micrometer is necessary to determine the mantle shrinkage noticeable after the mantle has been burned for a considerable period. The micrometer in question is mounted upon a hardwood base and consists of a pair of vertical uprights, guiding a platform, which is elevated or depressed as the case may be by a micrometer screw. A scale is laid off on one of the uprights to determine the elevation of this platform, together with a divided head on the micrometer screw. Sliding horizontally on the platform are guides to which caliper fingers are secured. The mantle may be mounted on the burner, which in turn is mounted upon a stud in such position as to bring the mantle between the caliper fingers. The distance between the fingers is determined by a direct reading vernier on front of the platform.

With this instrument the shrinkage of the mantle may be determined from time to time during the endurance test with absolute accuracy, and may be in turn plotted so as to show graphically the condition of the mantle at the various stages of the test.

The incandescent mantle, as you are well aware, is fragile and should be handled with the greatest care to avoid at all times indenting or creasing either before or after the collodion protecting coating has been burned off. Mantles for testing purposes should be handled with great care from the mantle maker to the laboratory, as it quite frequently occurs that mantles break soon after test has been started, which results in great loss of time and material. This is due to the fact that the mantle after leaving the manufacturer may have been subjected to a severe shock, which has not resulted in any injury so far as its appearance before burning off is concerned, but may cause

it to disintegrate after the protecting coating has been burned away.

The standard incandescent mantle is $3\frac{1}{2}$ inches long and is measured from the lower end to the uppermost point of the ash. It should lap for a distance of one-half inch over the burner cap or carrier. Any variations in these dimensions will, of course, make a considerable difference in the candle-power of the mantle, hence for the purpose of making a test these measurements should be recorded with considerable care. The burner should be placed vertically on the gas outlet, taking care that the orifice in the check of the Bunsen and the intermediate gauze located in the burner head are perfectly clear and free from dust. As the user is instructed to blow the dust out of his burners occasionally, it is quite necessary that they should be blown out in a similar manner during an endurance test; otherwise results will be obtained which might appear due to deterioration of the mantle, while in reality its candle-power is affected by the dirt in the burner, which would destroy its ability to entrain the proper amount of air for proper combustion. The coating should be burned from the mantle by lighting at the top. If any carbon still remains it should be removed by turning down the gas at the check.

The glassware should be perfectly clean when placed on the burner and the mantle should be allowed to burn for about a half hour before starting the test, at which time also the diameter and length of the mantle should be taken carefully with the mantle micrometer, starting at the head and calibrating down the mantle at intervals of one-quarter inch.

In making a mantle endurance test after the initial reading has been made, the gallery of the lamp carrying the mantle should be removed and a mica chimney substituted for the testing chimney. The burner may then be transferred to another room and allowed to burn for a period of 100 hours. On second reading the burner should be removed from the bar and dust which may have accumulated during this period blown out. The glass chimney should then be replaced and a reading made and the mantle calipered as before. Other readings should be taken at 250, 500, and 1,000 hours.

It is very important before making a reading to see that the glassware is perfectly clean, as well as the burner, for if a test is made without doing this, it does not represent a test of the mantle but rather results in a combination mantle, burner, and chimney test and the results obtained mean absolutely nothing.

At the time of making each reading it is absolutely necessary to determine the value of the gas used, such as its calorific value, candle-power, gravity, etc.

The glass chimney should be marked so that the same side always faces the sight box. It is also necessary to see that the same side of the mantle faces the sight box at each reading, unless, of course, a mean horizontal plane reading is made.

The chimney should be standard eight inches, clear, thin, hard, heat-resisting glass, 1 15/16 inches outside diameter. When air-hole chimneys are used, a deck plate should be used to seal the base of the chimney, thus compelling all the air for the outside of the mantle to pass through the holes in the chimney, the neck of which should be of such length as to bring the center of the air holes immediately opposite the gauze line of the burner.

In making a comparative test either of a burner or mantle or both, we first test a standard $3\frac{1}{2}$-inch mantle mounted on a regular burner with eight-inch clear glass chimney. In this way we roughly check any unusual conditions which may exist, which might otherwise lead one to a false conclusion when testing a new device.

For comparative work merely the horizontal candle-power is taken. If

during an endurance test it is found that the gas has changed to such an extent as to be appreciable, it would be better not to make a second test until a gas could be procured similar to that used when making the initial reading. While this to the lay mind might seem unnecessary, if one is to determine with any degree of accuracy the real value of the mantle this precaution must be taken, for while we may approximate our results on different gases it is at best unsatisfactory, as I know of no law by which we may accurately correct for the variations in the gas.

DISCUSSION

Mr. W. C. Morris, of New York, said that it would be very difficult to discuss Mr. Litle's paper, as he had covered the subject so completely that only minor things suggest themselves. In reading over the paper his attention was particularly called to what might seem small contradiction in the making of tests or using photometer table, and he would like to emphasize a little the necessity of that.

Recently in making some tests we found some very variable candle-powers and after a long and weary search we found a length of pipe exposed for some nine or fifteen feet to a cold draft or a warm draft, according to the time of day, and after covering it with the proper covering our candle-power went along in peace. It merely brings out the importance of small things.

Also he mentioned the connection of candle-power with the pipes on the table. That is another very important thing. Any one familiar with the work of manufacturing stations knows how he can get good results in summer time. Mr. Litle says it is a good thing to clean out pipes. I would like to know something that will clean them out and not damage the candle-power after they are cleaned.

He also refers to the use of the thirteen-inch bar. The speaker had been a great advocate of the long bar, but there were times when a 100-inch bar or longer is disadvantageous, and that is when operating with lights of different intensities. You can get your lights so far apart that the eye cannot determine the difference in intensity, and in that case a sixty-inch bar is of greater advantage than 100-inch.

Also he refers to some apparatus connected with rubber tubing. In very delicate work that would be dangerous, as rubber tubing may give results that are not entirely true.

Mr. Litle also refers to the use of screens on a photometer bar. He noticed in the reproduction of the photograph that the bar only had two screens, and his experience had been that unless the light-sources, especially if large, are not so screened that light is prevented from reaching the eye from the side, that is exteriorly from the bar, there is a possibility of causing an error in the reading, and it is not only necessary to prevent reflections getting to the side disk, but it is necessary to prevent reflections getting to the eye.

In regard to working from both sides of the photometer bar: In checking up some eight or nine men on reading from the bar which was graded from both sides of the scale, he found very wide differences in the results; in fact two or three men read as far apart as two candles on the two sides of the bar. With knowledge as to your own errors he did not think it is necessary, but in an ordinary operation where more than one operator is working he thought more accurate results can be obtained if readings are taken on both sides of the bar.

Mr. Lansing said that relative to the number of screens for cutting off light that the last speaker just mentioned, he would like to call attention to the photometric laboratory of the Bureau of Standards at Washington, under charge of Dr. Hye. The laboratory is an ordinary room with white walls and white ceilings, and when he first went there he wondered what sort of photometer room that was and what sort of photometers could be had. Dr. Hye, however, uses a large number of screens to get light and some very exhaustive examination to find the effect, if any, of white walls and ceilings on tests, and he has shown that the error due to white walls and ceilings when screens are carefully made is far under 1/10th of 1 per cent, in fact in the neighborhood of 1/100th of 1 per cent; so that an ordinary room can be used and the effect is very much better on the person doing the tests than in a dark room; that is the psychological effect working in a dark room is sometimes gloomy, and if you can work in a light, cheery room it is very much easier to work in such a room, but, of course, it is very necessary to have the light thoroughly screened.

He noticed in the photographs Mr. Litle showed, that all the instruments and the room and everything were absolutely black. I think that could be done away with.

Mr. Victor A. Rettich regretted very much, only having just returned to the city, so that the paper was placed in his hands this morning, because the subject was one which could be enlarged upon indefinitely and he would like to have pre-

pared a paper on the subject. However, speaking as a gas man, he thanked Mr. Litle very heartily for bringing this subject forward at a time when the gas men have to compete with the electrical field, which is in such a state of activity, with their new incandescent lamps, for which they have instruments of precision by which they can accurately measure and claim their measurements, whereas in the gas business manufacturers of burners are making exorbitant and misleading claims, such as claiming 300 candle-power on three feet of gas, and nobody is in a perfect position to fully contradict them. Let us hope that now Mr. Litle has driven in so heartily the thin end of the wedge, that we shall keep on driving until the measurement of the light from an incandescent gas lamp will be as positive and precise as the tests conducted with the electric bulb.

It would be very desirable, although he was speaking as a competitor of the Welsbach Company in their burner trade, if they would put out a standard burner free from ornamentations. At this point he felt it his duty to pay a tribute to the products of the Welsbach Company, and suggested that they put out such a burner at a reasonable price, so that inventors could then test various gas checks if their trend of invention was along these lines, or try different mantles with the Mason occluding plate check if their interest lie with mantles, or the same mantle on another burner if the burner was claimed to be a better one.

Dr. C. H. S. Hayes said that this paper deals with the photometry of incandescent gas lamps. Now that means the measurement of the luminous intensity of incandescent gas lamps. We find that incandescent gas lamps, like a good many other sources of light, give a different intensity according Mr. Litle has not gone into and it would to the direction from which you choose to measure them. This question of the intensity of the light of incandescent gas lamps from different directions is one that Mr. Litle has not gone into and it would seem in the case of incandescent gas lamps an important question, just as in the case of all other illuminants. For instance, an incandescent gas lamp is set up and the candle-power is measured in a horizontal direction and that is called its candle-power. That is right and very good. But perhaps the candle-power in the horizontal direction a few degrees one way or the other from that position may be something less, and no account is taken of this. he would like to ask Mr. Litle if no attempt is made in the photometry of incandescent gas lamps to determine the mean horizontal candle-power as well as the candle-power in a certain direction.

When we come to the case of inverted mantle burners a very nice question comes up as to the reading of these in candle-power. What is the candle-power of an inverted mantle burner? He would like to know what the tendency of gas practice was in this direction.

He would like to ask Mr. Litle if the mean candle-power of incandescent mantle burners, both vertical and inverted, is not a matter of considerable importance and what appliances are commonly used in gas technics to determine it. Also the reduction power of mantle burners, that is, the ratio of the mean spherical candle-power to the mean horizontal candle-power.

He would like to ask also if there is not some approximate relation which connects the percentage rate of change of candle-power in the mantle burner with the change in the calorific value expressed in per cents.

With regard to a point brought up by one of the previous speakers as to conditions in photometry. This matter was investigated by Dr. Matthews, of Cornell University probably twenty years ago. He showed that the ordinary Bunsen photometer is a very one-sided instrument, or rather that the people who use the Bunsen photometers are one-sided, even though the photometer at first was intended so as to eliminate differences. In other words, if you ever get a true comparison of different lights, one of which is at one end of the photometer bar and the other at the other end of the bar, you must make them standing first on one side of the photometer bar, and then on the other side of the photometer bar, or at first in front of the photometer and then with your back to it looking at it from a mirror. This, however, does not apply to photometers in which one eye is used to make the setting.

The Reichsanstalt in Berlin has a fine photometer room with white walls. The Bureau of Standards also have a photometer room with white walls. They do work of high precision in those rooms. They have a good deal of trouble doing it because the walls are white and they have to avoid with a great deal more care reflections from walls than they would have to do if the walls were dark. His opinion of the white wall question was that a white wall photometer room is all right if you cannot have a black wall photometer room. He did not consider that it is a scientific discovery of high value that it is possible to have photometer lamps in rooms with white walls. You go into one of these white photometer rooms and notice that certain portions of the walls are covered with a very excellent black, and have to be, so that while it is not necessary to cover the whole wall black and you can get along with most of the wall covered with white if you are

careful, yet it is a matter of great convenience to have a room which you can paint black and make a photometer room of it. He would question also the effect of white walls of the room in changing the sensitiveness of the eye of the observer who is working in it.

Mr. W. F. Lawrence wished to ask Mr. Litle what kind of a disk he uses in the photometer he described, whether it is a disk of the ordinary star type, or whether it is a disk made of a wedge of chalk or of a white material.

Dr. Sharp wished to ask what degree of accuracy is obtainable in precision gas meters of the Arthur type?

Mr. Williams asked how the Welsbach mantle is seasoned for standards, and also what effect the shrinkage of the mantle has. Does burning a mantle of a different quality or kind of gas from that which is used to make the test on the photometer, affect the mantle in any way, the life of it or the showing?

Would there be any advantage or disadvantage in using the incandescent electric lamp for the standard of comparison? And, incidentally, he would offer a suggestion with regard to Dr. Sharp's remark on the Bunsen screen. In his practise he had found that if he looked at the screen with one eye on one side and the other on the other, he did not get as accurate results as he did by looking with both eyes first on one side and then on the other.

Mr. Lansing asked what is the relative effect on mantle burners and ordinary open gas in the change of the quality of gas? That is to say, if the quality of gas changes the candle-power of the mantle changes. What would be the relative change in the candle-power of ordinary open gas? Which is the greater variant?

Mr. Millar said he disliked to add to the burden which Mr. Litle already has placed upon him, but would like to know a little more of the significance of the shrinkage test, not only upon the candle-power but upon the light and upon the burner adjustment, if any. And also what significance is given to that in computing the value of the mantle as the result of the test. Is the value of the mantle stated in terms of candle-power, or are other modifying values given?

Another question. Assuming a test is undertaken, it will require two or three days for completion; the calorific value and other qualities of the gas are determined at the beginning of the test. Upon the second day the different value of gas quality is found. What is done? Do you proceed with the test, making some corrections, or do you wait until the quality found at the beginning of the test is again available?

The question of glassware is touched upon in a recent publication. Some preliminary tests are shown which cast grave doubts upon the superiority of the glassware. He would like to know if any work had been done which could be considered reliable and authoritative, looking toward the determination of the relative merits of these two kinds of glassware.

Another question is the mutual candle-power values of gas mantles. Within what limits of candle-power variation does a normal group of mantles of the best quality fall? About what percentage limit variation would we expect under a given set of these conditions?

Mr. Morris raised the question of the use of the Bunsen photometer and that was followed up by some statements with regard to the necessity of observing from both sides of the bar. Another way of doing away with the errors mentioned is the use of the substitution method. For example, if a Pentane lamp is being used and it is placed, let us say, at the right end of the bar, and a secondary standard is placed at the left end of the bar and then the Pentane lamp be removed and the testing lamp be placed in the same position, all errors due to reflection, lack of symmetry in the photometer and in the eyes of the observer are done away with largely if not altogether.

Mr. Lansing had the impression that it had been determined that the error due to white walls in a photometer room was well within 1 per cent. As he remembered that investigation, that was simply an error due to reflection of the light from the glass bulb on the incandescent electric lamp. The error due to white walls may vary one in one day, and then, due to the displacing of a screen, may be much larger or smaller. Recently he had been doing a considerable amount of photometry in connection with illumination tests where the work had to be done in a lighted room, and sometimes in a very brilliantly lighted room, and he found that the necessity for adapting the eye for observing the photometer after looking into the illuminated walls of the room was very fatiguing. He believed those same measurements if carried out in a dark room would not fatigue the eye to any such degree.

The Chairman was interested in reading about Flicker photometers, especially as used for lights of such different colors as are the light given by an incandescent mantle and the light given by a Pentane lamp, and wondered if Mr. Litle had any experience with the Flicker photometers and what his opinion of them was.

In regard to the error spoken of by Mr. Morris due to not looking at the disk from both sides of the bar, he thought, as Mr. Williams stated, that that can be very largely eliminated by not trying to

look at both sides of the disk at the same time, but by looking first on one side and then on the other. Then you use both eyes in each case and there is no chance of difference between the eyes coming into play.

He would try to answer a question Dr. Sharp had asked as to the degree of accuracy of an Arthur meter. There is no reason why an Arthur meter if properly calipered and properly looked after should not be accurate to within 1/100th of 1 per cent. It is merely a question of adjusting your water line accurately and not using your meter as a football.

Mr. Litle, replying to the question, why not take the mean horizontal candle-power of a mantle? thought that unless you do take the mean horizontal candle-power you must always take at least the same size of mantle. There may be some change, of course, but we don't find as much variation in different directions on the mantle that we do from incandescent lamps. I am not very familiar, of course, with electric phototometery, but they are twisting the filaments in such peculiar shapes now that they throw a great deal more light from one direction than another, but in the incandescent mantle you don't have so much change. As to the mean spherical that is also very necessary at times, particularly when glassware on the mantle is being considered. The various shapes of glassware and globes would give different results. You find, for instance, on the electric arc lamp an alabaster globe is used which may have been particularly designed to throw a particular amount of light. He recalled the case of a pear-shaped globe. In that case, of course, it was quite advantageous to take the mean spherical. We find in a great many cases it is simply necessary to take the mean lower vertical candle-power.

As to the screening of the bar, he thought it is very desirable for several reasons, particularly so in using an incandescent lamp, as one is liable to look backward and forward. It is very bad practise to look directly at the mantle in trying to read the side of it, because then it is very difficult to see properly. Mr. Williams had asked how a mantle may be seasoned. He simply meant a mantle that had been aged. We do notice from our endurance tests that after a mantle has burned for several hours, it burns constantly and deteriorates more slowly, and after a mantle has been burning along for a few hours it keeps up pretty uniformly, and he took a mantle like that.

Some one asked about the electric standard. He considered it a very fine standard. He mentioned the Pentane standard as being rather simple; it can be used and is very convenient, but for a perfectly equipped laboratory an electric standard seemed to him ideal. He had been through the testing laboratory there and knew that they are pretty perfectly equipped.

As to the relation between the candle-power to be expected from a mantle, he had not been able to find any definite data. He had read of statements where they have been able to approximate very nearly, but did not know of an authority that deals with that directly. He would like to have one that absolutely proved it. We can approximate it very closely, but we have not, as far as he knew, an authority that gives it absolutely. It makes a considerable difference in photometric work to use one gas one day and a richer gas the next day. It makes such a difference in fact that the resulting test, is rather a test of the gas than a test of the mantle or of the appliance, and, therefore, the photometer room should be equipped with at least a fifteen-foot holder, which is enough to run for a day.

As to the shrinkage of a mantle as affecting the candle-power: Of course, a very bad shrinkage would lessen the illuminating surface of the mantle, contracting the meshes and interfering with the combustion of the gas.

As to air-hole glassware, as compared with the cylindrical glassware, he thought it was pretty well conceded that the air-hole glassware is not as efficient. In air-hole glassware you can use a larger chimney and prevent breakage. That is one of the reasons it is used. It will not break so easily. Probably the glassware being further removed from the mantle has consequently less breakage, and if you take that into consideration you have a gain; but the extensive use of air-hole glassware of irregular shapes is very bad. Simply because a piece of glassware has air-holes in it does not make it efficient. None of the varieties of air-hole glassware did he find as efficient as the straight chimneys.

As to the initial candle-power of the ordinary mantle and what is to be expected from an ordinary mantle: From a good 5½ inch mantle with an 8-inch chimney, 1 1-16 inches in diameter, you can expect about 100 candles burning on about 4½ or 5 feet of gas. Now it is perfectly possible to get higher candle-powers from a very light and fragile mantle, but the mantle in that case is not a commercial proposition, because it is extremely light and fragile. The lighter the mantle, the more candle-power you can get, but, on the other hand, they won't last.

One of the audience wished to ask what is the percentage of deterioration from the initial candle-power after 100 hours of constant burning. Say, for instance, if you start out with an initial candle-power of

100. After a period of 100 hours what is the percentage of deterioration?

Mr. Litle replied that the drop at the end of the first is greater than at the end of the next 100 hours. And while the mantle may depreciate to the extent of say 30 per cent, the drop is greatest during the early part of the burning. That depends, of course, upon the mantle. Those very light mantles drop off very rapidly the first 100 hours. They may run along the rest of their life pretty steadily; but it depends on the mantle. The burning of the mantle is greatest during the first 100 hours. The heavier the mantle the less the drop. The lighter the mantle the greater the initial candle-power and the greater the drop.

Mr. Morris asked about the effect of the calorific power of gas upon the candle-power of the incandescent mantle.

Mr. Litle said he had not actual figures at hand. It isn't so great as would be imagined; that is, you can have a gas of varying calorific value without so much altering the candle-power of your mantle. But the lower the value of the gas the more of it is necessary to produce a certain result. As to the efficiency, the efficiency would change. The efficiency curve would be greatly different and the candle-power curve might not be so different.

Mr. Lansing asked how the candle-power of a mantle made of cellulose instead of cotton would compare with the ordinary cotton.

The Chairman called attention to Mr. Millar's question as to the variation in candle-power of mantles of the same batch.

Mr. Litle said that, of course, mantles are not made in a mold, and, therefore, have different shapes, and it is simply impossible to make two mantles just exactly the same shape, the same diameter, the same kind of head, etc., and consequently you naturally expect some difference in the candle-power. Those things change its light-giving properties. You have to expect a difference. If you asked what that exact difference is, he could not tell you offhand. However, with modern mantle practise we are able to hold the shape pretty well. There is not very great difference. It is possible to get mantles that don't vary more than 7 or 8 candle-power. And considering the method of manufacturing mantles, that is rather remarkable.

About the cellulose mantle, personally he had not threshed that out enough to give you a good answer on it. It is not now a commercial proposition. It may become one. He had seen different mantles made by different processes which gave different results, and what we may expect from continued experiment he thought it too early to mention definitely. He had seen experimental mantles made which gave very good results.

Mr. Lansing asked if the experimental mantles show up as well as the other, or better.

Mr. Litle had not seen any that would give a marked increase. He saw some that were rather lower. He thought the shape of the mantle limits that as much as the material in the mantle. Some of those mantles have a very peculiar shape, very different from the standard mantle. Then you could hardly condemn a mantle because it gives less candle-power: it may be due to the shape as much as to anything else.

Papers Read Before Technical Societies

NEW INCANDESCENT LAMPS

By J. Swinburne, F.R.S.

Read before the Institution of Electrical Engineers, Jan. 10, 1907. (Abstract.)

A little more than a quarter of a century ago several men were working out the arc lamp, and inventors were bringing out what they called semi-incandescent lamps. People's ideas were very obscure in those days and much confusion was due to the mis-statement of the problem that was really waiting for solution.

One of the first to understand the real nature of the problem and the proper means of solving it was Edison. He realized that high-resistance lamps could be worked in variable numbers in parallel on constant-pressure circuits. This seems so obvious now that we cannot understand where the difficulty came in; but if you will look up the technical press just before 1880, you will find people's ideas very chaotic. At this stage there were evidently two things necessary for distribution: a small lamp, and high pressure. Edison seems to have begun with a high pressure especially in view, and Swan, on the other hand, studied the small lamp. The curious thing is that once platinum was put aside, it was always assumed that carbon was the only material possible. Certainly, there were some experiments on silicon. As silicon is very closely related to carbon, it seemed likely that it would make a good filament, but nothing came of it. Attempts were also made to coat carbon filaments with silicon and with boron.

It may seem strange that people did not experiment on some of the more refractory metals; but a little consideration will explain matters to some extent. The output of lamps was much smaller than at present, and, therefore, the inducement was less. Very little was known about the refractory metals, and the measurements of high melting points was more or less impossible.

Apart from these, there was the mechanical difficulty of working up the metal into a very fine wire, and now we have to face the problem of making the wire sufficiently fine to enable the lamp to be used on circuits of 200 to 250 volts, notwithstanding low specific resistance. Squirting has made it possible to make carbon filaments as fine as desired, the difficulty now being that of mounting the filaments. If the surface emission is the same, the pressure varies directly as the square root of the cube of the length of the filament. Other things being equal, a 200-volt filament is nearly 1.56 times the length of the 100-volt conductor and about two-thirds of the diameter. It is thus very much weaker. Weakness is not by any means the only consideration, however. The slow wearing of the surface causes a greater percentage difference in the resistance of the lamp, and there is double the pressure available for causing discharge across from one leg of the filament to the other. The only way the lamp maker can reach high pressures, other things being equal, is by increasing the size of the lamp—that is to say, making 16- instead of 8-candle-power lamps, and so on.

We have thus the distribution engineer clamoring for high pressures, and the lamp maker trying to meet his demand, and making up to 250-volt lamps. The lamps are naturally worse than those made for lower pressures.

The improvement introduced by Mr. Howell—namely, the heating of carbon filaments in an electrical furnace to convert them into a form of graphite—is really perfecting an old process rather than inventing a new one. The effects of high temperature were known long ago. Filaments heated electrically without deposition from gas were found to be hard and flexible and black, and in some cases had about the same resistance hot as cold. They were more durable than carbon-coated filaments. The American lamps are probably a development of this idea.

But as soon as we deal with metal lamps the question of distribution comes up again. How are lamp makers to get the metal wire so fine that it will take, say, 200 volts? If a carbon lamp of 200 volts and 16 candles has an efficiency of 0.25 candles per watt, it must have a resistance of 625 ohms. But a metal lamp is made to work at, say, 0.75 candle-power-watts, and that means that for 16 candles there are only 21.4 watts. This means a resistance of 1,870, or nearly 2,000 ohms, as compared with 625 ohms. There are two influences which help the metal lamp, however: the resistance of the metal rises considerably with the temperature, as a metal is run not very far from its softening point, and the emissivity of bright metal is less than carbon, so that to give the same light at the same efficiency the wire may be larger. It seems probable, however, that bright metal surfaces increase the emissivity as they get hot—that is to say, they get blacker as they get hotter, a black body being brigter at a given high temperature than a white body.

We thus come upon the weak point of

the metallic lamp—it is very difficult to make a small lamp of 200 volts. The questions are, therefore, whether the higher efficiency of the metal lamp will induce us to bring our pressure down to 100 volts or less, on the one hand, or whether the metal lamp can be made to take 200 volts or more either by further perfection by the use of some sort of transformer, or by using larger lamps, say, 50 candles each. People are not likely to use lamps in series to any great extent, or to provide low pressures. The metal lamps may get a certain footing on 100-volt circuits. It seems probable, however, that people's ideas of the value of light will alter, and that incandescent gas or large metal lamps will soon lead them to use 50 candles as the normal light at each point. At the same time, the ingenuity which has made metal lamps possible seems quite capable of making 200-volt 16-candle-power lamps within reasonable time.

When we come to the question, What metals or compounds are available for lamp filaments? we have to consider the melting point, the specific resistance, and the possibility of making the filaments in practise. As to the melting point, it has been quite impossible to melt many of the metals until the electric furnace came into use; but the electric furnace generally deals with the metals in the presence of carbon, which probably alters their melting points. But apart from that, before the recent development of the study of radiation, there was no means of measuring such temperatures as the fusing point of tungsten, for example. Even yet we have no data as to the melting points of most of the refractory metals. The best guide available is the periodic law, by which the elements are divided into groups, the elements in each group having similar characteristics. By using elements whose melting points are known to be high as a sort of guide

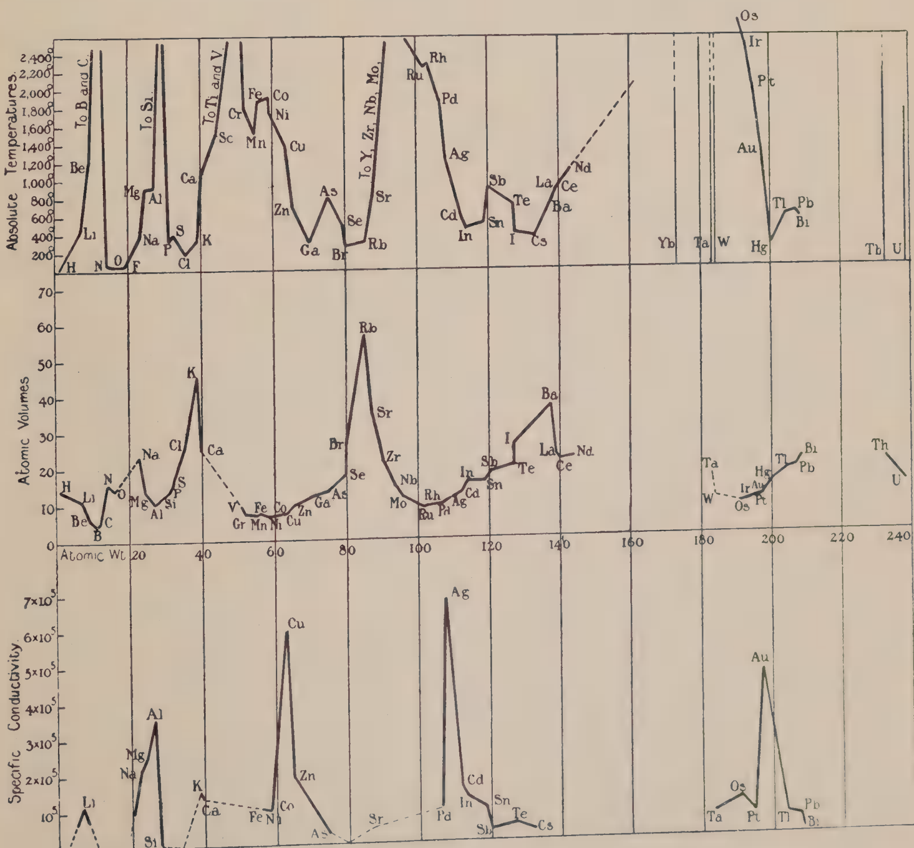


FIG. 1.

—	I.	II.	III.	IV	V.	VI.	VII.	VIII.	IX.
1	H −269								He
2	Li 180	Be under 1,000	B	C	N −215	O 235	F 223		Ne
3	Na 96	Mg 800	Al 657	Si	P 44	S 114	Cl −102		Ar
4	K 58	Ca 760	Sc	Ti 2,500	V 1,620	Cr 1,600	Mn 1,280	Fe 1,503 Co 1,500 Ni 1,427 Cu 1,084	
5	Cu 1,084	Zn 419	Ga 30	Ge 1,400	As 500	Se 250	Br 7		Kr
6	Rb 39	Sr 900	Y	Zr 1,300	Nb 1,850	Mo		Ru Pd 1,900 Rh 1,520 Ag 962	
7	Ag 962	Ca 322	In 176	Sn 224	Sb 632	Te 450	I 116		Xe
8	Cs 27	Ba 1,150	La 800	Ce 623	Di 940P 840N		Sm 1,350		
9					Er				
10			Yb		Ta 2,150	W above 1,900		OS 2,200 Ir 2,250 Pt 1,710 Au 1,064	
11	Au 1,064	Hg −39	K 290	Pb 327	Bi 269				
12		Ra		Th					

posts, we can thus pick out the elements most likely to have high melting points.

Instead of using a table of elements we may work from curves. Fig. 1 shows three curves. In all of these the horizontal distance is the atomic weight. In the top curve the height is fusing point; in the middle curve, atomic volume; and in the lower curve, conductivity. It must be admitted that the information obtained is very vague, and it can be used only as a sort of index to show the probable directions for success. The melting points when high are very indefinite, so the peaks of that curve have been omitted. There are very few accurate data available as to conductivity of the metals.

It will be seen that the high melting points correspond with small atomic volumes. Electrical conductivity seems to follow the same sort of rule.

In making metal or carbide filaments there are several processes.

A carbon filament may be made first, and this may be coated by electrical heating with other substances, and the carbon can then be volatilized.

The same process can be carried out except that the carbon, instead of being volatilized, is combined, making a carbide. A wire may be deposited electrolytically from a solution.

The material may be ductile, in which case it is drawn into wire in the usual way.

The material may be made into a very fine, smooth powder, and mixed with some agglomerant and squirted. The squirted filament is then dried, baked, and heated electrically to get rid of carbon if an organic binding material has been used.

An oxide may be mixed with carbon and made into a paste and squirted. The filaments, after baking, are heated electrically *in vacuo;* the carbon then reduces the oxide, making either metal or carbide according to the proportion of carbon employed. The carbon may be supplied by heating in hydrocarbon vapor.

The oxide may be made into a rod and run like a Nernst lamp, except that the process is carried out either *in vacuo* or in hydrocarbon gas, so that the oxygen is removed, leaving metal.

These are the most likely, or the least unlikely ways of making filaments. There are others which figure in patent literature a good deal. The laws of nature, as revealed in patent specifications, are so extraordinary that I do not feel justified in confusing your minds with them.

The account in the technical papers of the methods used by the inventors may not always be absolutely true in detail, and they frequently have quite a suspicious flavor of patent specifications.

The plan of coating a carbon and then volatilizing the carbon by heat has a heroic ring about it, which promises a lamp capable of very high efficiency; but I want to see it done. Most metals are likely to form carbide rather than let the carbon go off.

The Cruto lamp of about 1884 was supposed to be made by the converse process of depositing carbon on a fine platinum wire, and then heating the carbon till the platinum boiled off. The actual filaments were of such low specific resistance that platinum must have remained there.

The electrical deposition of metal filaments is generally troublesome because most of the metals that might do for lamps will not deposit uniformly enough, and electrolytic deposits of hard metals are not capable of being drawn down into wire. For such a process to be successful the core or mandrel must not be made of a metal that will form an alloy. It need not necessarily be metal at all; presumably such a material as nitrocellulose coated with blacklead, or made conductive by any of the ordinary

methods, would serve. The resulting filaments would be tubes, of course.

Drawing down fine wire is generally impossible, as few of the metals are ductile. The drawing down of tantalum by Messrs. Siemens & Halske is a perfect triumph when not only the real but the reputed properties of that metal are considered. Whether they draw the metal down by itself or by the Wallaston method I do not know. Tantalum is not soluble in the ordinary acids.

It might be urged that alloys should be used for lamp-wires, on the ground that many brittle and intractable metals may make ductile alloys. There is another point; alloys have generally high specific resistances, and this is, of course, a very great point. Even a very small addition of another metal may increase the specific resistance very considerably. Unfortunately alloys generally have low fusing points. Where a very fusible and a refractory metal are alloyed, the addition of the refractory to the fusible metal generally lowers the melting point. If the metals have about the same melting point, their alloy may be taken as having a lower melting point. This is not a law, however. It is possible, therefore, that alloys may be formed which have very high melting points.

The addition of a very little of one metal to another may be worth while if it increases the specific resistance very considerably and lowers the melting point very little. Where you add a trace of infusible to a fusible metal the first result is generally to reduce the melting point; but after a very small percentage the melting point rises very rapidly. If you begin with the infusible metal, the addition of the fusible component brings the melting point down very rapidly. In alloying two metals of about equal melting temperatures, the first addition of either brings the melting point down rapidly.

Alloying has a possible disadvantage in reducing the resistance temperature coefficient. The rise of resistance is a most valuable property in a wire lamp, as it protects the lamp against overrunning and allows it to be run bright on a more variable supply current.

One of the difficulties in squirting filaments of a paste of finely divided metals and an agglutinant is to get the metal fine enough to squirt smoothly. This is also a question of the agglutinant used. Some of these metals in the form of powder will not squirt properly; the paste comes out thin at first and then particles choke the nozzle and the squirting stops. Gum tragacanth is a very convenient material to use. After a metal filament is squirted it must hold together until it is heated to a temperature high enough to sinter the particles together and make the filament into a sort of wire. Obviously it must be difficult to make very fine filaments in this way; and very fine filaments are necessary for reasonably high pressures. If the agglutinant is carbon there is a chance of its being taken up by the metal and either making the carbide or reducing the melting point, just as the carbon reduces the melting point of iron or manganese.

Squirting a mixture of oxide and carbon and then electrically heating to get metal, does not look promising, because the resulting filament will probably contain carbon, or be a carbide, or else the metal will be only a sort of framework, as the volume of the metal must be less than the volume of the oxide plus enough carbon to reduce it. Such a filament will have a large diameter for a given weight of metal and will most likely be very weak.

It may often be easier to squirt a very fine filament of pure oxide than of metal powder. The oxide can then be reduced in many cases in hydrogen or even carbon monoxide, without forming carbide. In some cases I have found very fine "impalpable" powders can be made by calcining such salts as the oxalates. Prolonged kneading has a marked effect on the extrudibility of many pastes. A paste is much improved by being worked for hours in a small Pfleiderer, or by more powerful kneading. The attrition of the particles seems to grind their corners off. Starch and water will not squirt well. Gum tragacanth may act partly as a smooth cushion which prevents crystalline or angular particles locking; but prolonged kneading appears to grind off the corners.

A filament made by reducing a paste of oxide with hydrogen is also more likely to be dense and strong than one which had the reducing material in its body in addition.

The method of making a squirted filament of oxide and reducing it by running it as a Nernst lamp *in vacuo* is troublesome, and does not give much promise of supplying long, thin filaments. If you consider the length and diameter of the Nernst rod for 100 volts, and compare it with a tantalum wire for the same pressure, it is evident that the method is almost hopeless. A wire the length of a tantalum lamp filament and approximately of the same diameter could not be made of oxide, and could not be run as a Nernst filament with any reasonable pressure if made.

Though metal filaments have been referred to so far, it must be remembered that there is no reason to limit the possible conductors to elements. To begin with, we have the first of the new lamps, the Nernst, made of oxides. The stick of ox-

ides, or glower, as it is generally called, has such a high specific resistance that it need not be long and thin to meet ordinary conditions. On the other hand, the rods cannot be made very thin, as the oxide is soft when hot, and is fragile when cold. The smallest rods are for 0.25 ampere. On 100 volts these give 16 candles. The makers do not make rods to take 0.125 ampere so as to give 16 candles on 200 volts. As the lamp requires a heater to start it, and an electro-magnet to put the heater out of circuit, and a series resistance, or "ballast," it has always appeared to me that the real field for the Nernst is not in competition with the 16-candle carbon incandescent, but in the region of 50 to 500 candles. The proportion of cost of the electro-magnet, the resistance, and the heater is smaller in this case, and there is a more open field in competition with small arcs and Welsbach mantles.

The Nernst glowers used to be a mixture, of yttria, or "yttrite earth" with zirconia, and it is probable the same or a similar mixture is still used. There may be a very large field for improvement here. The conditions are that the rod should stand a high temperature without getting too soft, and it should begin to conduct at a low temperature, so that starting should be easy. On the other hand, the lamp is of course patented, so there is not much encouragement for workers making improvements. It may be thought, however, that it would be better to employ some black substance, such as some oxides or sulphides which conduct even cold, so that preliminary heating might be omitted. It is a very curious thing that there does not seem to be any such black or colored compound in existence.

It may be supposed that a Nernst glower should be run *in vacuo* so as to avoid the loss by convection. The glower appears to conduct electrolytically exactly in the manner of a fused salt; and it would further appear that with a direct current you would get oxygen at one terminal and zirconium at the other, and that in a few minutes the glower would be entirely reduced to zirconium if the oxygen were pumped out as liberated. What really happens is that the lamp goes out. It does the same in an atmosphere of coal gas. This may be because the zirconium is liberated in a modification which does not conduct.

Zirconium is said to fuse fairly easily; on the other hand, people are said to make lamps of it. As a matter of fact, it is not easy to get such a metal as zirconium pure, and it is quite possible the melting point is very high and that some particular alloy that was really being examined melted more readily. Nearly all the melting points of such metals are uncertain. Zirconium lamps are made for up to 110 volts at 1-candle-power.

Tantalum is an exceedingly hard metal, and in its pure state is ductile. It has a specific resistance of 16.5 microhm centimetres cold, or about 85 at the temperature of a lamp. It has a high tensile strength, namely, 93 kg. per square mm., or 59 tons per square inch.

It is drawn into wires of 0.05 down to 0.035 mm.; the large wire gives 25-candle-power lamps on 110 volts. Such a lamp has a filament 65 cm., or 25½ in. long and a pound of tantalum will make 20,000 of these lamps (Böhm). The tantalum is melted in an electric arc or furnace, and the ingots are heated red, and hammered into sheet, and the sheet is drawn down into wire. Messrs. Siemens & Halske intend to make various uses of the marvellous properties of tantalum, and we shall probably soon have tantalum pens, drills, cutting tools, unoxidizable springs, and other desirable objects.

Messrs. Siemens & Halske do not recommend their lamp for alternating currents, and it cannot, therefore, be as good as on direct-current curcuits; but it runs on alternating currents very well—though perhaps not as long. On the other hand, it is said that the alternating current alters the physical nature of the wire, rendering it brittle, so that it breaks, not by fatigue, but by any slight shock it happens to get. The Nernst lamp has shown peculiarities in this connection. Some glowers will run with direct and not with alternating currents, and some with alternating only. Direct-current glowers also go wrong if the poles are changed. These mysterious properties of the Nernst do not seem to have anything to do with the behavior of the tantalum lamp, however, but all the same there may be something in common. It is said that the makers have now overcome the aversion of tantalum lamps to alternating circuits. I have heard of tantalum lamps running on the county of London alternating circuits for over 600 hours with no failures. The makers attribute the breakage to the trembling action due to the repulsion of the wire near the bends. This will most likely be overcome by making the zigs and the zags so that the wire does not come close to itself. At present they are very acute angles. The wires are often in movement through a sort of Trevelyan rocker effect at the points of contact of the wire with its numerous supports.

Molybdenum is very similar to tungsten, and unless the melting point is lower than that of tungsten, we shall probably soon have molybdenum lamps. The trioxide (the anhydride of molybdic acid) is volatile, and might, therefore, be used for de-

position of molybdenum on a carbon filament, so as to replace it.

Tungsten is a very hard and brittle metal, which is sold in the form of a black powder, or as ferrotungsten. It was for a long time considered infusible, but the electrical furnace showed, of course, that it could be melted. The powder is difficult to squirt, even mixed with a good deal of tragacanth. Kuzel has invented what seems to be an admirable way of getting over the difficulty. He gets the tungsten in the form of an exceedingly fine powder by employing a method that was used by Bredig for getting what is known as colloidal platinum. An arc is made to play under water between tungsten electrodes, and this is said to produce a very finely divided form of metal. This is collected and worked up into a stiff enough paste and squirted. Tungsten is not an expensive metal, so the only cost is in making the filaments. Whether the filaments of this paste can be squirted so as to be fine enough for 200 volts will be a matter for the future to decide.

There have been processes proposed or worked in which carbon is heated in a vapor of a volatile tungsten compound, such as the trichloride, or oxychloride, in the presence of hydrogen. If the reduction in the case of a chloride is due to the hydrogen, thus involving no oxidation of the carbon, a filament must be obtained of carbon coated with tungsten, or of carbide of tungsten, but if there is any oxygen involved in the reduction, as in the case of the oxychloride, the carbon is burnt out, and the result is a filament of tungsten.

Osmium is a crystalline metal, which cannot be drawn into wire. It is very hard, scratching quartz. The Welsbach osmium lamp is said to be made by making a paste of finely divided osmium and an organic binding material, and squirting it. The filaments are then baked, and heated electrically to a very high temperature to eliminate the carbon. The osmium lamp so far produced is for low pressures, as might be expected, but it has a very high efficiency.

Making lamps of osmium must be an exceedingly difficult matter. Apart from the metal being very hard and infusible, it oxidizes in the air if very fine, though this oxidation does not take place if the fine powder has been heated to a high temperature. The peroxide of osmium formed is very poisonous. It gives off enough vapor at ordinary temperatures to give much trouble, and especially to injure the eyes very seriously. This oxide might be used for replacing a carbon filament with osmium. No doubt that has been tried. The osmium, was, I think, the first of the new metal lamps, and was invented by Auer von Welsbach. It is made up to 75 volts with 40 candles by the Vienna firm, now the Westinghouse-Metallfaden- Glühlampfabrik, but 100-130-volt lamps of only 32 candles are supplied by the General Electric Company, of this country. The rated efficiency is 0.8 candle-power-watts.

The osmium wire is said to be as small as 0.03-mm. diameter, which is rather less than the finer tantalum wire.

There is some doubt whether the lamps known as osmium are made of osmium or tungsten. Tungsten is a curious metal, and it is not very easy to get into alloys, but it may alloy with osmium perfectly for all I know to the contrary.

Iridium is a very hard and brittle metal. Iridium lamps are being studied by Gülcher. He makes a paste with an organic binding material, and squirts it. The filaments are then heated electrically until the carbon is burnt out, and some particles of metal have sintered together. This lamp, like other metal lamps, labors under this disadvantage of being only for low pressures. It would seem that squirted metal filaments are less likely to be made fine than those made from drawn wire.

It will be asked, What will be the effect of these new lamps on the industry? In the first place, they will increase the output of stations, just as machinery increases labor. But there is more difficulty in foreseeing the result of high efficiency hampered with low pressure. A probable solution is that people will gradually take to using large lamps taking the same pressure, and about the same power as carbon lamps, but giving say, four times the light.

As to the lamp-making industry, one might prophesy without much danger that the present makers will merely alter their manufacture and make metal lamps. This will pay inventors better, because the existing makers have their commercial organizations and their facilities for distribution. Besides, all the works except the parts devoted to making the filaments will be available. It is possible new works will be set up to make filaments, and that the lamp makers will buy the filaments, and make them up into lamps. There are so many possible ways of making metal filaments, that it is doubtful whether large monopolies can be secured by patents; and it is much more likely that most of the present carbon lamp makers will work out particular processes of their own, and will put their own metal lamps in the market.

INVESTIGATIONS ON LIGHT STANDARDS AND PRESENT CONDITION OF THE HIGH VOLTAGE GLOW LAMPS

By Clifford C. Paterson

Read before the Institution of Electrical Engineers. (Abstract.)

Summary.—The author gives an account of investigations carried out at the National Physical Laboratory. The first part of the paper (which we give in abstract in this issue) deals with standards of light. Harcourt's 10-candle-power pentane standard, the German Hefner and the French Carcel standards are described, and the effect of humidity and other atmospheric conditions upon their accuracy are considered. Life curves of Fleming-Ediswan lamps, as secondary standards, are given, and the conditions for their accurate use are laid down.

The second part of the paper deals with commercial glow-lamp testing.

COMPARISON OF FLAME STANDARDS

Investigations were undertaken two years ago at the instigation of the Institution of Gas Engineers with the object of determining the ratio between the candle-powers of the three principal standards as used by the gas industries at the present time in France, Germany and Great Britain. The International Photometric Commission, on which the Institution of Gas Engineers is represented, arranged for similar tests to be made in France and Germany in order to obtain a set of independent comparisons which enable the ratios between these standards to be defined with more certainty and greater accuracy than at present.

The results of tests in France and Germany, although completed more recently have already been published.* The standards to which reference has been made are respectively the Carcel, the Hefner and the 10-candle-power Harcourt pentane lamps. In all measurements which are described here, special care has been taken in the manipulation of the lamps so as to conform to the same regulations and practise which are observed in the countries in which they are the recognized standards.

INFLUENCE OF ATMOSPHERIC CONDITIONS

It is now generally appreciated that atmospheric conditions have important influence on the candle-power of flame standards. Dr. Liebenthal,† at the Reichsanstalt, was the first to make quantitative measurements in order to determine the amount of their influence on the candle-power of lamps. He investigated two standards, the Hefner lamp and the Woodhouse & Rawson 1-candle pentane lamp, and the formulæ (referred to later in this paper) which he found for correcting the Hefner lamp are now generally accepted.

In a photometer room the principal variations to which air is liable are the following:

(1). Variation in the amount of carbon dioxide.

(2). Variation in the amount of water vapor.

(3). Variation in the proportion of oxygen and nitrogen.

(4). Changes in barometric pressure.

Before any measurements with flame standards can be considered reliable, it must be ascertained that the air is under standard atmospheric conditions, at least as regards 2, 3 and 4. If the conditions be abnormal, the amount of water vapor in the air as well as the barometric pressure must be known.

Carbon Dioxide.—In order to determine the effect, if any, of variations in the amount of CO_2 present in the air, samples of air were taken from the neighborhood of the lamps whilst observations were being made. The air was slowly drawn into previously exhausted 10-litre vessels which, when full, were tightly stoppered and examined at the end of the observations.

Hours after lighting up.	Candle-power of pentane lamp.	CO_2 in litres per cubic metre.	Water vapor in litres per cubic meter of pure air.
. .	10.06	0.55	9.0
$\frac{3}{4}$	9.75	0.9	10.6
$1\frac{3}{4}$	9.60	1.4	11.0
$3\frac{1}{2}$	9.45	1.8	11.8
$4\frac{1}{4}$	9.33	1.9	12.2

Table I.

In order to increase the effect, the amount of CO_2 was artificially increased to 1.9 litres per thousand—the photometer room being closed, and candle-power readings taken over four hours. The results of such an experiment are given in Table I. After correcting for the increase of humidity, the decrease in candle-power after 4¼ hours amounts to some five per cent, which is very little in excess of the observed decrease when the lamp is merely left burning in an ordinary closed room.

Dr. Liebenthal found, from experiments in which he artificially increased the amount of CO_2 to 14 litres per cubic metre, that the candle-power of the Hefner lamp varied 0.7 per cent for an increase of 1 litre per cubic metre. As the amount of CO_2 in a closed room, 5 x 6½ x 4 metres, in which the lamp has been burning for upwards of one hour, only varies from about 0.5 to 0.8 litre per thousand, the influence of carbon dioxide on the candle-power of flame standards may be considered, for practical purposes, as negligible.

Water Vapor.—The amount of water

vapor in the air is the most disturbing factor to be considered in dealing with flame standards, as it cannot be remedied by ventilation of the photometer room. There are large natural variations in humidity throughout the year, and rapid changes from day to day.

The total variation, for instance, in the candle-power of the pentane lamp between a warm damp day in summer and a frosty one in winter may amount to ten per cent, and between two consecutive days it is frequently two or three per cent, the changes in the Hefner lamp from this cause being very little less than in the pentane.

The author reproduces in Fig. 1 a curve which he has already published showing the effect of variations in the humidity of the atmosphere on the candle-power of the pentane lamp; candle-power is plotted vertically and humidity horizontally. The latter, for obvious reasons, is stated volumetrically, and is expressed as the number of litres of vapor per cubic metre of dry air. If, therefore, e stands for the aqueous pressure, then the water vapor per cubic metre of pure air litres, where b is the reading of the barometer.

On the assumption that the variations follow straight-line laws, the following formula is obtained connecting candle-power and humidity for the 10-candle-power lamp:

$$\text{Candle-power} = 10 - 0.066(10 - e),$$

where e is the number of litres of water vapor per cubic metre of dry air.

It will be observed from this formula that the candle-power of the lamp has its standard value when the volume of water vapor is 10 litres, which is very nearly the mean humidity over the three years 1897-98-99, both at the Meteorological Office in Victoria street and at the Observatory Department of the National Physical Laboratory.

For the Hefner lamp the formula obtained from these observations is (the candle-power being expressed in terms of the pentane lamp)—

$$\text{Candle-power (pentane units)} = 0.914 + 0.006(8.8 - e).$$

Dr. Liebenthal, from the average of a much larger number of observations made over a greater range of humidty, found a formula which, using the ratio of Hefner to pentane as 0.914, gives the following relation:

$$\text{Candle-power (pentane units)} = 0.914 + 0.005(8.8 - e).$$

As this is based on more numerous data, it should be accepted in preference to that given by the author for the Hefner lamp. It may be noted, however, that the difference between the two formulæ produces a discrepancy of under one per cent in candle-power even for an extreme case.

A similar set of experiments was made with two Carcel lamps, but the want of constancy in the lamps themselves introduced inconsistencies into the results which were of a greater order of magnitude than the largest change produced by such range of humidity as was obtainable at the time of the year. The results show that the Carcel lamp cannot be relied upon for constancy to the same extent as the other lamps.

The Proportion of Oxygen and Nitrogen in the Air.—The author is not aware that any quantitative measurements have yet been made on the diminution of candle-power due to a scarcity of oxygen in the photometer room. The author has made measurements in a closed room of 130 cubic metres capacity and finds that the candle-power of the pentane lamp falls about one to one and one-half per cent in one hour. Mr. Dow‡ has recently published some curves showing results of tests made at Kensington in a room of about 400 cubic metres capacity in which, with two persons in the room and two gas burners alight, the candle-power dropped some 2.5 per cent in one hour.

In a small closed photometer room, in which no effort is made to ventilate, a variation of from seven to ten per cent may quite possibly be obtained.

With a small unit such as the Hefner lamp the trouble due to this cause is not so great, but it may safely be said that under no circumstances is it safe to use a flame standard in a room which has not very efficient ventilation.

In the case of a 10-candle-power pentane lamp no measurements should be relied upon which have been made after the lamp has been burning in a closed room for more than fifteen or twenty minutes, unless, of course, the source of light which is being measured is affected in the same way by atmospheric changes.

These facts illustrate how misleading may be the results obtained from comparisons made against a flame standard unless proper precautions are taken and the necessary corrections applied. Suppose, for instance, that the lamp is being used in a room in which the ventilation is bad, and causes, say, a drop of 1.5 per cent in the candle-power of the lamp. If the day be hot and damp and the barometer low the 10-candle lamp will be giving a light of the order of 9.2 candles, and the Hefner lamp under the same conditions will be only slightly more accurate.

Barometric Pressure.—Under normal conditions the amount of variation due to this cause does not give rise to such large errors as changes in humidity. With a high barometer the candle-power tends to rise,

but the amount of the increase or decrease varies considerably with the type of flame —being 0.8 per cent per 10-mm. variation in barometric pressure for the 10-candle pentane lamp, and (according to Dr. Liebenthal) 0.1 per cent for the same variation in the case of the Hefner unit. The author has found 0.2 per cent in the latter case, whilst Dr. Liebenthal finds 0.0 per cent in the former. The same authority has found 0.4 per cent in the case of the 1-candle pentane flame.

The formulæ which are most probably correct for expressing candle-power variations due to barometric changes are as follows:

Pentane lamp: Candle-power=10—0.008 (760—*b*).

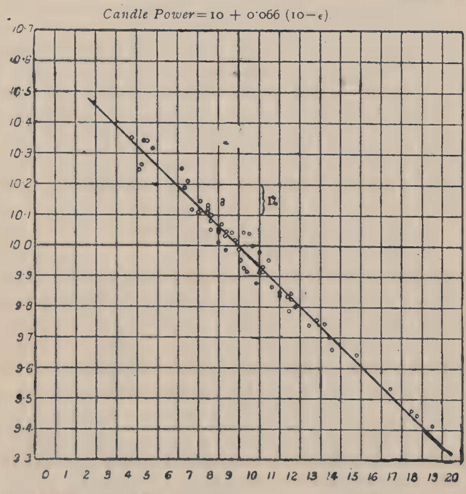
Hefner lamp: Candle-power=0.914—0.0001 (760—*b*).

(Pentane units.)

PHOTOMETRIC METHODS

The foregoing notes on the variation of standards with changing atmospheric conditions make it clear that it is not sufficient, in comparing any two flame standards of different types, to fix them up on the bench and measure the ratio of their candle-power, without regard to the state of the air, on the assumption that they will both be affected equally by it. Unless the atmospheric conditions at the time of observation happen to be standard, or very nearly standard, it will be necessary to make a series of candle-power comparisons with hygrometric and barometric readings. A formula has then to be deduced from which the candle-power, under standard conditions may be found.

The double comparison, or substitution method, described by Dr. Fleming in the paper already mentioned is much to be preferred to direct comparison. By this method a constant source of light, such as an electric lamp, is fixed at one end of the bench, and the two flame standards to be compared are alternately measured against it.



Cande Power of Pentane Lamp corrected to a Barometric Pressure of 760 mm. of Mercury.

DESCRIPTION OF THE LAMPS

The 10-candle Harcourt Pentane Lamp.—The details of this lamp are too well known in this country to require any but a brief description.

Liquid pentane is contained in the rectangular saturator at the top of the lamp. Air passes in at one of the cocks, and being drawn round baffle plates over the surface of the pentane, passes down a rubber tube to an argand burner. As far as the author is aware, the extent to which a variation in the dimension of any part of the lamp affects its candle-power has not yet been determined.

The Metropolitan Gas Referees state in their notification that in regulating the height of the flame to about midway between the bottom of the window and the bar which crosses it, a variation of a quarter of an inch either way does not materially affect the candle-power of the standard. The statement may be accepted, provided the accuracy required is not greater than about one per cent. If, however, measurements are to be within this limit of accuracy, it is essential that the flame shall be kept at the right height. Dr. Liebenthal finds that the flame may rise above the mark but not fall below it. The author's experiments, however, confirm those of other observers in showing that Mr. Harcourt has so proportioned the dimensions of the lamp that when the flame is at its correct height its candle-power is a maximum, any variation above or below the normal height causing a decrease in candle-power. This is a point which is greatly in favor of the lamp, as it means that a certain variation of height is possible, within which it is easy to regulate the flame, and within which the candle-power does not perceptibly vary. By affixing a piece of rubber tube to the air inlet cock on the saturator, and regulating the flow of air through it by an ordinary screw clip, a most sensitive means of flame adjustment is obtained. The observer also is able to stand at such a distance from the lamp that he will not disturb the steadiness of the flame through air currents set up by breathing near it. From this point of view the lamp compares favorably with the Hefner standard, the flame adjustment of which, in spite of the ingenious optical device employed, is a matter requiring great patience and entailing some uncertainty.

The lamp, after carefully setting up, is

lighted up and all doors and windows of the room are thrown open. The lamp is allowed to burn in this way with a free circulation of air for half an hour. The electric comparison lamp is then brought up to its correct voltage by the potentiometer, and all windows and doors closed before taking readings.

The author has not yet found any photometer which, for the same colored light, is equal in sensitiveness and accuracy to the Lummer Brodhun contrast apparatus, which has been used in all the experiments described in this paper. Some twelve or fourteen readings are made during the first ten minutes after the room has been closed, together with observations on both ventilated and unventilated hygrometers placed at different points in the neighborhood of the lamp. It is desirable for one observer to remain at the photometer, and on no account to see the position of his own settings, whilst another adjusts the flame and takes down readings.

As regards the accuracy of photometric observations made under these conditions, much depends upon the condition of sensitiveness of the observer's eye on any particular occasion. This is certainly a variable quantity. The author has found on some occasions that ten readings will agree amongst themselves to within plus or minus a quarter of one per cent, whilst on others the extremes are occasionally as much as plus or minus one per cent.

The Hefner Lamp.—The construction of this lamp, which is the official standard of light in Germany, is simple. Amyl acetate, passing specified tests for purity, is contained in the cylindrical resevoir which forms the base of the lamp. A wick dips into this and passes up the thin-walled German silver tube projecting from the centre of the base.

The wick, however, does not rise above the top surface of the tube, but, keeping about level with it, serves to conduct the liquid to the point of ignition. The exact thickness, diameter, and height of this tube are some of the most vital points which determine the candle-power of the lamp. The flame is a lambent one, and resembles in general appearance that of an ordinary candle, except that it is circular in cross-section. The exact height at which it gives one Hefner candle (about 0.9 English candle) is 40 mm. In order to adjust the flame to the correct height the lamp is fitted with a sighting arrangement, in which an image of the top of the flame is cast on a ground glass disc and adjusted to a cross line.

The general precautions to be observed as regards ventilation when using this lamp are the same as for the pentane standard, except that the room may be closed somewhat longer while readings are in progress before the candle-power of the lamp shows signs of diminution.

Considerable care and skill must be employed in judging whether the flame is at its correct height. The author has observed a tendency for the flame to vary its shape from one which is high and pointed to one which is somewhat depressed and flattened at the top, and an error in candle-power may result from taking either of these as correct, and adjusting either the pointed or the flattened flame to the level of the cross line. The same effect has been remarked by Messrs. Laporte and Jouaust.

The Carcel Lamp.—The Carcel lamp is the working standard of the French gas industry. It has a glass chimney and a wick of annular cross-section to which a continual supply of pure colza oil is maintained by means of a clockwork pump. According to the official instructions, the wick should stand 10 mm. above the wick holder, but in practise this is found to give too great a consumption of oil, and it is necessary to lower it to 7 mm. or 8 mm. in order to approximate to standard conditions. The chimney is made of thick glass, and reduced in diameter 7 mm. above the wick.

The lamp should give its standard candle-power when consuming forty-two grammes of oil per hour. As the exact height of the glass chimney above the wick, and the depth to which the wick is charred, affect the rate of consumption, it is very difficult to adjust to the forty-two grammes per hour. The actual consumption is therefore measured, and provided it falls within thirty-nine and forty-six grammes per hour the candle-power is corrected accordingly. There is some doubt, however, whether this is strictly accurate, M. Laporte having found that for a given variation in consumption the candle-power change is proportionally too great.

Various precautions must be observed when using the lamp. For each experiment the oil and the wick must be new, and the latter should have been previously stored in a desiccator in order to ensure absence of moisture. As soon as a full stream of oil is circulating over the wick, the latter should be charred to an even depth of about 2 mm. all around by means of a flat-flame burner. The lamp may then be lighted, turned very low, and the chimney fixed so that the neck presses close down on to the wick.

Under these conditions there is only a very shallow ring of flame, which tends to equalize the intensity all round the wick. After about fifteen minutes burning in this condition the chimney is raised, the wick turned up, and after twenty minutes' burn-

ing the lamp is counter-poised on a balance on the photometer bench. A weight of ten grammes is then added to the scale on which the lamp is fixed, and the time observed before the balance again swings over. The correct time for a consumption of ten grammes per hour is fourteen minutes seventeen seconds.

The author has found that, after taking a large number of observations, and using the utmost care in all the adjustments, he has been unable to make readings from the lamp agree with certainty to within an accuracy of + or — three per cent.

In any two directions at right angles the light from the flame may vary as much as two per cent, and to ensure even the three per cent limit of accuracy it is generally necessary to take a mean of four readings round the flame in directions at right angles to each other in a horizontal plane.

SUMMARY OF RESULTS

In summarizing the results of the tests described here, and comparing them with those made in other laboratories on the Continent, it is essential to take into consideration the fact that the Hefner lamp in Germany has its standard value when the volume of water vapor is 8.8 per 1,000 litres of air, whereas both the pentane and Carcel lamps are taken as having their nominal value when the humidity is 10 litres per 1,000.

The following values have been obtained for the Hefner and Carcel lamps by the author, and are in the terms of the 10-candle Harcourt pentane lamp:—

Hefner lamp=0.914 pentane units.
Carcel lamp=0.982 pentane units.

The following table gives the values for the same ratios recently obtained and published by the Reichsanstalt in Berlin, and by the Laboratoire Centrale d'Electricité and Laboratoire d'Essais et Conservatoire in Paris. Expressing the values of all the units in terms of that given by the pentane lamp, we have:

——	Pentane.	Hener.	Carcel.
National Physical Laboratory.... 2	1	0.914	0.982
Reichsanstalt....	1	0.917	0.991
Laboratoire Centrale.......	1	0.929	1.000
Laboratoire d'Essais.......	1	0.928	0.996

TABLE II.

COMPARISON AND CRITICISM OF THE THREE LAMPS AS STANDARDS OF LIGHT

The measurements made at the National Physical Laboratory on the three principal flame standards now in use have given opportunities for comparing them under working conditions and judging of their respective suitability as standards of light.

As regards the Carcel lamp, it has not been found that its constancy from day to day is comparable with that of either the Hefner or pentane lamps, its variations from the mean being as much as + or — three per cent. The reason for this can only be attributed to the difficulty in reproducing the same conditions of capillarity in the wicks used. Although all possible care was taken to produce the most favorable conditions of constancy the results were not satisfactory, and in the notes which follow the pentane and Hefner lamps only are considered with reference to their suitability as light standards.

General Construction.—The Hefner lamp, which is only one-eleventh the candle-power of the pentane lamp, is much simpler in general construction, small and more easily set up, and should be simpler to manufacture and adjust to standard dimensions.

Ease of Regulation and Working.—It has been found in using the lamp that the flame of the 10-candle pentane standard is a great deal easier to adjust, and remains more constant while observations are being made than that of the amyl acetate lamp.

The fact that the Hefner unit has a lambent flame, burning in free air, whereas the pentane standard is well shielded and, owing to its chimney, has a more stable flame, makes the latter practically independent of draughts which would render measurements with the Hefner lamp quite impossible. Although the flame of the Hefner lamp may be shielded, slight movements of the air cannot be avoided; these disturb the flame so that it only remains at its correct height for a few seconds together, rendering adjustment difficult and the taking of candle-power readings rather a tiring process.

On the other hand, it is not safe to assume that, owing to the fact that the top of the flame of the pentane lamp is cut off, the latter may be allowed to vary appreciably in height. Variations of 3 mm. up or down, do not materially affect the candle-power, but for accurate work a second observer is required to see that the top of the flame is flat and to regulate it to the correct height.

Effect of Atmospheric Changes.—As regards changing humidity the two standards are affected to nearly the same extent, the Hefner lamp being slightly less influenced than the pentane lamp. The latter standard, however, is very much more sensitive to barometric variations than the Hefner unit, an inch change in pressure being equivalent to two per cent in candle-power.

The Nature of the Light.—The pentane lamp has a whiter light than the Hefner unit, being much more nearly the same tint as the Carcel standard.

The fact that its candle-power is eleven times that of the amyl acetate lamp makes it of the same order of magnitude as the

ordinary lights which are tested against it.

These two factors, coupled with the greater ease of adjustment when making observations with the pentane lamp, greatly outweigh, in the author's opinion, the disadvantages of the more complicated construction and the larger correction that has to be applied for changes in barometric pressure.

THE TEMPERATURE OF FLAMES

By W. H. Y. Webber

Delivered before the London and Southern District Junior Gas Association, Jan. 16, 1907. (Abstract from the *Journal of Gas Lighting.*)

In his opening remarks, the speaker cautioned his hearers against wasting their money and time on old text-books, though he admitted that there was, of course, much that they must learn and have by them for reference which never grew out of date—such as arithmetic, mathematics, geometry, mensuration, and the tables of properties and constants appertaining thereto. But they should never buy encyclopedias or subscription books with tempting prospectuses, which were necessarily out of date before they were published. The newest of any text-books that they felt in need of, official publications, such as Blue-Books, the notifications of authorities like the Metropolitan Gas Referees, the transactions of societies, and the technical press, would be found of greatest use to them. With even the latest and most expensive text-books, however, he pointed out that they must be prepared for the passing over of many things that they particularly wanted to know, and the stopping short of others precisely where the author's criticism would become helpful. He cited the seventeenth edition of Ganot's work on Physics, dated 1906, and edited by Professor A. W. Reinold, as affording an instance of this; the calculation of flame temperature not being dealt with there in the manner that a student buying an expensive text-book had a right to expect. "Yet," said Mr. Webber, "Professor Reinold must have known quite well that the question of the real temperature attainable by flaming combustion lies at the bottom of a large and highly important body of technic. Metallurgists want to know what to expect from the gaseous fuels at their command. Manufacturers of the harder kind of porcelain and glass goods need the information. The whole body of incandescent gaslight practise depends upon the fact of high flame temperature. Lord Rayleigh, among others, pointed this out years ago. Yet the uninstructed, fumbling makers of this light, like Mr. A. W. Onslow, are fain to go on with their work in their own way, without the smallest help or guidance from the magnates of science.

Reference was then made to the researches of Professor Vivian B. Lewes and Professor Arthur Smithells. Mr. Webber remarked that Professor Lewes, in his lecture to the Institution of Gas Engineers on "Candles and Calories" in 1903, laid stress upon the fallaciousness of the idea that the temperature of the flame was governed by the calorific value of the gas. Professor Lewes stated that the temperature of the flame produced by the combustion of the sample of gas depended (1) upon the time in which this volume of gas was consumed, (2) upon the area in which the combustion took place, and (3) upon the amount of air needed for completing the combustion, and the specific heats of the products of combustion of the flame and the residual nitrogen from the air, which in their escape removed heat from the flame. This "effect," as it might be termed in philisophical language, of flame temperature, he concluded, was the important thing in incandescent gaslight production. "Professor Lewes," continued Mr. Webber, "described certain experiments showing for blue water gas, purified from CO_2, with a calorific value of 325 B.Th.U. net, a light efficiency in the Welsbach 'C' burner of 19.38 candles per cubic foot hourly consumption at 13-10ths pressure. The illuminating power of the light in this case was 158 candles for a consumption of 8.15 cubic feet per hour. Observe here the satisfaction of all the conditions previously laid down by Professor Lewes as governing flame temperature. We start with a particular size of substance to be heated by the flame—to wit, a 'C' mantle. If this mantle were heated as in the ordinary way by a flame of mixed town gas and air, the former having a calorific power of 540 B.Th.U., or thereabouts, and burned at the rate of four cubic feet per hour, which would just about fill it, the same average duty per cubic foot of gas might be expected—meaning, that the mantle would be at approximately the same temperature. The amount of air required for complete combustion would be nearly double. The high temperature attained by the water gas is therefore due to the comparatively smaller size of its flame. Professor Lewes puts the flame temperature of coal gas here at about 1660° C. (which is low); and quotes Blass for a water-gas flame temperature of 1775° C. It was also shown that a temperature sufficiently high to yield a brilliant light at 20-10ths pressure can be attained, by careful air regulation, with an exceptionally good quality of producer gas of 184 B.Th.U. net calorific powder. But meanwhile others had been busy upon the problem of the connection between the calorific power

of gases and their value for the production of incandescent light by the Welsbach mantle. Dr. Bunte, Dr. Colman, Mr. F. D. Marshall, and others, independently hit upon the same guiding principle—that within the ordinary range of differences in the calorific value of town gas, of various makes, the duty obtainable from the gas and a mantle is about the same—adjustment of the air supply being understood. Mr. W. R. Herring has also carried the same discovery to conclusive demonstration."

Coming to Prof. Smithells' work, the lecturer referred to his address in 1905 to the Institution of Gas Engineers, on "The Temperature of Flames," in which was explained why the classical rule for calculating flame temperatures had not correspondence with the facts. Professor Smithells described how Bunsen made a shot at the problem, with results far from correct; and he proceeded to explain the phenomenon of dissociation, and most instructively indicated the part played by it all in making mixed flames as thick as they were. That was to say, as he (Mr. Webber) understood him, it was due to the deferred combustion effect of dissociation that the flame of a Kern or a Mecker burner was not a mere filmy appearance at the zone of ignition, as would be the case if the mixed gases could burn all at once at the initial temperature of their combustion. Professor Smithells thought that flame temperature calculation could be carried out, but did not offer any examples; and the broad result of all the study he (Mr. Webber) had been able to devote to the problem was that he could not ascertain from its composition what degree of elevation of temperature to expect from the burning of a particular sample of combustible gas or mixture of gases, while on all sides he heard complaint of the want of this information.

By means of fine strips of wire, and some Bunsen burners which were fitted up in the room, the lecturer next demonstrated the fact that the temperature of flames varied greatly in different parts; and he also quoted figures on this point. Taking a common laboratory Bunsen flame, with an air adjustment, enabling the inner cone to be varied from the blue tint of underaeration to the green of approaching backlighting, Professor Lewes gave the following as the measured flame temperatures:

	With Blue Inner Cone.	With Greeni Inner Cone.
At tip of inner cone........................	1994° Fahr.	2867° Fahr.
Centre of outer cone........................	2791° "	2966° "
Side of outer cone, level with tip of inner cone	2431° "	2752° "
Proportion of air added to the volume of gas	2.27	3.37

Tests made at the National Physical Laboratory on the same subject showed:

Temp. of Centre of Flame at	Ordinary Bunsen.	Mecker Bunsen.
2 mm.	100° C. (212° Fahr.)	1520° C. (2768° Fahr.)
10 "	100 " (")	1470 " (2646 ")
20 "	150 " (302)	1460 " (2596 ")
40 "	500 " (932 ")	" " (" ")
60 "	1100 " (2020 ")	1470 " 2646 ")
80 "	1350 " (2462 ")	1430 " (2351 ")

Pointing out that the hottest part of the flame in ordinary Bunsen burners was in the solid region over the inner cone, while the Mecker flame was solid, and hottest at the bottom, Mr. Webber said this went to support the "dissociation" explanation. He remarked that other observers gave different maxima for these Bunsen flame temperatures, and then proceeded to consider the question of the temperature of a mantle as compared with that of the flame in which it was plunged. Assuming that the mantle possessed a sensibly greater heat than the gas flame, he asked whether this was due to the catalytic action of the mantle (as Professor Lewes once thought), or whether it was caused by the purely mechanical effect of the meshes of the mantle in completing the mixture of air and gas, presenting the mixture from inside to the rapid action of the outside or secondary air in such a fine state of division as to secure the best possible final combination. He himself believed there was much in the latter explanation, and that those who studied inverted incandescent lights and their activating Bunsen flames would agree that the mantle did something else besides glowing. Returning to the lecture of Professor Smithells, Mr. Webber remarked that one of the valuable observations contained in it concerned the relationship between flame volume and flame temperature. With gas burning at a fixed rate, the smaller the volume of the flame, the higher must be its temperature. Professor

Smithells explained that the way to get a small flame was to have it mixed primarily with the largest possible portion of the air it required for its combustion. This effect, said Mr. Webber, was strikingly exemplified by the Mecker burner. The Kern burner also exhibited compression of the flame; while its formation was specially moulded to the object for which it was made. The Bray and Sugg mantle-burners were designed somewhat on the same lines. Professor Harold B. Dixon pointed in the same direction in 1904, when he said that "the burning of a highly explosive gas mixture is one of the best means of developing light from gas;" the light-giving power, of course, being synonymous with high-flame temperature.

Continuing on this branch of his subject, the lecturer remarked: The question of getting as much primary air as possible into the burning mixture was worked at by the late Mr. Frank Livesey, and by Mr. Walter Grafton, your ex-President, and it underlies the "Selas" system of intensified lighting. In point of fact, what all the high-pressure incandescent gas lighting systems now before the world do, is nothing more or less than make the best mixture of gas and air possible, and drive the flame through the mantle at a high velocity. There is no actual pressure within the mantle; the pressure of the gas in the pipes being translated by the injector into velocity. This means, according to Professor Lewes's formula, burning more gas in the time and space, which is one way of raising the flame temperature, and so producing more brilliant incandesecnce. The degree of elevation of temperature attainable by this method depends upon several factors. How far the pace can be profitably forced, having regard to economical considerations, is another question again. Some tell us that, in the general way, an intensity of incandescence corresponding to a supply pressure of from fifteen to seventeen inches of water is enough. Other practitioners prefer to work at fifty-four inches pressure, which means double-wove mantles. So far as I know, this is the maximum for lighting burners. Mr. Onslow has kindly made, at my request, some comparative observations by means of the Féry pyrometer, of the temperature of incandescent mantles. From these, it appears that, as might be expected, the thermal radiation rises with the luminous intensity.

RADIANT TEMPERATURE OF INCANDESCENT GAS-MANTLES, IN DEGREES CENTIGRAD

"C" Burner with Chimney giving 60-candle-power. [Length of Mantle from Loop to Burner, 3⅛ Inches		Same Mantle *without* Chimney 50-Candle-Power
Temperature at the top	480 to 500	560
" 1⅛ inches from the top,	490	560
" 2⅛ " " "	470	610
" 2⅝ " " "	450	570
" 3⅛ " " "	400	520

600-Candle-power High Pressure Burner. High-Pressure Gas-Mantle with no Glass Protection. [Length of Mantle from Loop to Burner, 4¾ Inches.]		Same Mantle under Different Illuminating Power	
		900-Candle-power.	400-Candle-power.
Temperature at top of mantle	730	700	675
" 1¼ inches from the top,	735	705	680
" 2½ " "	740	710	685
" 3¾ " " "	745	720	690
" 4¾ " " "	755	730	705

High-Pressure 1000-*Candle-Power Burner.*

[Length of mantle, 5⅝ inches from loop to burner.]

	1000-Candle Power.	500 Candle-power. First Test.	5 Mins. after First Test.	800 C.P.
Temperature at top of mantle	710	690	690	690
" 1½ inches from top,	720	710	690	695
" 3 " "	730	720	700	790
" 4½ " "	725	720	705	705
" 5⅝ " "	720	705	700	700

High-Pressure 250-*Candle-Power Burner.*

[Length of mantle, 3½ inches.]

	265-Candle-power.	250-Candle-power. First Test.	After 5 Min.	200 C. P.
Temperature at top of mantle,	630	630	630	610
" 1 inch from top,	630	630	630	610
" 2 inches "	630	630	630	610
" 3 " "	645	650	645	620
" 3½ " "	650	645	635	625

The uniformity of the 1,000-candle-power mantle temperature may be due to the mantle tapering from the bottom to a narrow neck; whereas the 600-candle-power mantle is almost the same diameter throughout the length from 4¾ inches to within 1 inch of the top. This looks as if the two radiations, thermal and luminous, in the case of all the high-pressure mantles are of about the same proportions; the greater illuminating powers being due to the larger mantles of the more powerful burners. But the difference of the proportionate thermal radiation between the Welsbach "C" mantle and the intensified mantles is marked. I draw your attention to the remarkable fact that, though the local temperature at the mantles in these burners is higher than the melting point of platinum, which is 1775° C., the pyrometer only finds a temperature inferior to this by about 1100°C. This circumstance alone warns us that the measurement of flame temperature is not a simple task.

But this is not the whole of the story. Indeed, it is but a preface to the volume that has yet to be written upon the enthralling subject of the practical working aspect of flame temperature. The intensity of flame temperature may not be easily ascertainable by the classical method of calculation from the calorific value and the weight and specific heat of the combustion products, or by actual measurements; but it is very greatly affected by the proportion of incombustibles intruded upon it. The presence of nitrogen cannot be helped if we must burn our gas with air; but if oxygen were cheap enough, as Professor Dixon has remarked, it would be easy to increase the temperature of the flame by 500° or 600° Fahr.; and as radiation increases as the fourth power of the absolute temperature, the light duty of the same mantles that are now in use would probably be raised to 100 candles or more per cubic foot. On the other hand, admixture of an impurity having a high specific heat, as CO_2 is fatal to the attainment of the highest temperatures.

Another important conclusion to be drawn from this survey of the means of producing high-flame temperatures is that of the futility of the regenerative principle for this purpose. The effect of heating a gas is to dilate it, which is tantamount to diluting it. In the case of the Siemens type of regenerative burners, which worked at very low pressure, and had a luminous flame, the increased radiation due to raising the temperature was accompanied by extension of the radiating area of the flame. This is impossible with an incandescent mantle, which is of fixed dimensions; so that if the supply of gas and air is rendered bulkier by preliminary heating, regenerative or otherwise, the effect of the mixture in passing through the meshes of the mantle must be so much weaker that any possible gain by one way is more than neutralized by the loss on the other. Indeed, in the interest of concentrated action on the mantle, it would be better to condense the air and gas by cooling, than expand them by heating.

Mr. Webber concluded his lecture with a few remarks on the question of flame temperatures as applied to heating by gaseous fuel. He said that the next resource to the weak and uncertain producer gas was plain water gas, which, though its flame temperature was high, was troublesome to make and dangerous to distribute. There remained, therefore, ordinary town gas, as the gaseous fuel of unexceptionable utility for most industrial purposes demanding an intense, rapid, and localized heat. For this use a higher gas pressure than anything employed for lighting was found advantageous. Coal gas averaging about 540 B.Th.U. net calorific power, with a fire-brick lined cupola-shaped furnace, worked wonders, for instance, in rapid steel annealing at a pressure going up to 100 inches. This was a matter of flame temperature —which, however, had not yet been measured. Consequently, no man knew precisely, or even approximately, what town gas would ultimately do for the service of man.

OUTLINE LIGHTING

By Homer Honeywell.

Read before the Northwestern Electric Light Association.

The Lincoln Gas and Electric Light Company organized a new business department with a competent manager at its head, about the first of February, 1904, and started out with well defined ideas as to the desirable classes of business and the effects on the station load. It was the aim to take on a steady load that would run from dusk until midnight each and every night during the year, and to that end a flat rate was figured out based on the Doherty rate of $1.80 per year for each connected 16-candle-power lamp, or its equivalent; $12.00 per year for a customer charge and 6 cents per k.-w.-hour for energy used, all subject to a discount of 10 per cent for prompt payment, and on the actual number of burning hours as applied to Lincoln.

No flat rates are taken on inside lighting. We have free renewals and do it whenever our men see a defective lamp in use.

The outlining is installed free when two-year contracts are taken and the cost of installation figures about thirty-eight cents per 4-candle-power lamp installed, the lamps being spaced eighteen inches apart. By this method a number of small stores were induced to light up. The small merchant with a strip of seventeen 4-candle-power lamps over his sign burning each and every night from dusk until midnight. turned on and off by us, pays $5.30 net per month. At the present time there are in use the equivalent of 10,000 4-candle-power lamps, for sign, outlining and window lighting, and used by barbers, shoemakers, livery stables, undertakers, second-hand stores, bootblack stands, butcher shops, lunch cars and popcorn stands; in fact, all kinds of business. No business is too peculiar or small to be a "prospect." We have one customer, a clothing store, whose sign, outlining and window lighting, amounts to 960 4-candle-power lamps. This was the first customer to get in the game and we have used him as a pacemaker.

In soliciting we are always careful to impress on the propect's mind that the outside and window dislay is an advertising and not a lighting expense.

Solicitors are paid a small salary and a percentage of the increase in gross revenue over the same month for the previous year. Each solicitor's commission depends on the number of points he has in proportion to the total number turned in and points are given for each dollar of estimated revenue, as follows: Industrial business, ten points; additional inside consumption, ten points; new contracts, five points; outlining or signs until 12:00 o'clock, ten points; outlining or signs less than 12:00 o'clock, five points; outlining or signs on meter, three points.

If the business is taken from the competition the points are doubled. Each man is responsible for his own territory and is keen to hold business as well as to get new business.

Personal solicitation, newspapers, mail advertising and personal letters are used and the cost of getting business to the company for the past three years has been 43 cents for each dollar of increased revenue procured. The costs are divided as follows:

Advertising	.05
Construction	15.05
Solicitation	22.05

Of the advertising done at the start I believe the mail advertising was the most valuable. It was done on a fairly large scale and in a way that was new to a great many people. The first week one letter or card was sent out, the next week two, and so on until the prospect received a letter or card every day. The mail advertising helped put the prospect in a receptive mood and the solicitor was able to close quickly. The combination of mail advertising and personal solicitation is a strong combination.

The effect on the station has been gratifying. The increase in peak load has been twenty-three per cent., while the sales have increased sixty per cent. The sale of signs was not pushed particularly until we had made considerable headway in the other forms of lighting. At the present time we have forty-eight lamp-lettered signs in use. all of them bought outright from the local sign builder. The reason for installing free outlining on two-year contracts, and not installing free signs is apparent. The outlining can be taken down, be repainted and put up again anywhere at a very small cost, while a sign to be used again would have to be remodeled at a considerable expense. Then, too, the first investment for a sign is considerable, and if the merchant is not required to carry the investment he feels more free to discontinue the use of the light. During the past three years we have not had over five or six outlining contracts discontinued, where the merchant remained in business, but on the other hand most customers have increased their display.

There are in use 8,500 4-candle-power lamps for sign, outlining and sidewalk showcases. All these are on a flat rate. For window lighting, 900 16-candle-power lamps are used. Outlined roof signs also seem to be a popular and cheap method of advertising.

Review of the Technical Press

AMERICAN ITEMS

"Car Lighting," by R. C. Taylor, *Street Railway Journal,* February 2, 1907.

The general subject of car lighting is treated under the following headings: Headlight Requirements; Tail and Classification Lamps; Lighting the Interior; Arrangement of Circuits; Power Required; Resistance and Regulation; Use of the Compressor Motor; New Lamps.

On the subject of interior lighting, the writer gives the following interesting information:

"The fact that out of nine interurban lines running into Indianapolis, the interior lighting arrangements vary from twenty lights to sixty-five lights per car seems to indicate that there is still room for discussion on the best method of electric car lighting. The performance of these lights on the road and the quantity of light given out seem to indicate that there may be room to advocate some improvement in their arrangements."

Under the subject of new lamps, he makes the following general deductions:

"Given, therefore, a high efficiency lamp that may be made in small units, offering unlimited opportunities of correct distribution, and a constant potential on the lighting circuit, the proper illumination of a luxurious interurban car becomes a very easy problem for the engineer. Whether the high-efficiency incandescent lamp or a specially designed arc be employed in the illumination of a modern interurban car, they should be surrounded with a frosted or opalescent globe backed up with reflectors against a white background, giving a soft, pleasant diffusion of the light in all parts of the car interior."

"Car Lighting," by J. R. Cravath and V. R. Landsingh, *Electrical World*, February 2, 1907.

Illustrated by two half-tone cuts, showing the interior of a private electric car, and dining car of the usual type used on steam railways. The article is principally devoted to a discussion of the forms of lighting shown, particular attention being given to the weak points.

Gas Logic, a monthly magazine of enlightenment and progress; edited by Robt. E. Livingston.

We have already made mention of this really unique and admirable periodical, but a further perusal of its monthly use impels us to again bring it to the attention of our readers. While its ultimate purpose is to promote the commercial interests of the companies supplying gas to Greater New York, the little magazine is so exquisitely gotten up, the entire contents so fresh and interesting, and absolutely free from any of the taint or ear-marks of advertising as to place it in a class by itself.

Copies are cheerfully sent to anyone sending a request accompanied by a 2c. stamp, to Circulating Department, *Gas Logic,* 1 Madison Ave., New York City.

The contents of the February issue will give a fair idea of the range of matter which it covers.

The Lost Range.
Odd Corners where the "Slot" Meter is Found.
The Hostage.
How Light is Measured.
Birth of an Annual Show.
Home Entertainments.
Kitchen Magic.
Editor's Chat.
Prize Puzzle Picture.
Questions and Answers.

MUNICIPAL LIGHTING IN CLEVELAND

Municipal Journal and Engineer, Feb. 6, 1907.

The following information concerning the municipally-controlled lighting plant of Cleveland, Ohio, has been furnished by Mr. W. J. Springborn, director of the Board of Public Service. No allowance has been made in the figures for depreciation, but

the addition to the cost given for the years 1904, '05 and '06 of an amount ample to provide for this would still seem to show that the cost of service is lower than that previously paid. An interesting point is the reduction in cost of lighting and extinguishing lamps by the employment of students for this purpose.

During the four years, from 1900 to 1903, inclusive, all of the lamps in Cleveland were cared for by private contract. In the year 1904 the city undertook the care of all gas lamps paying the gas companies 75 cents per thousand cubic feet of gas consumed. Since that time it has been caring for all of these, and also what vapor lamps are still in service. The electric arc lamps, however, it still contracts for. The price of the last in 1903 was $75.00 per month; in 1906 a reduction had been made to $69.22 per lamp. The largest reduction in cost, however, is directly traceable to the saving in cost of maintaining the gas and vapor lamps.

The city uses what is known as the Welsbach incandescent burner of about 55-candle-power, for which it formerly paid the gas companies $22.00 per year per lamp. Under municipal control they have cost as follows: 1904, $12.56; 1905, $13.44; 1906, $13.17. During the last year the division of cost was: For gas consumed, $6.43; for maintenance, including every item of expense for supplies, extinguishing, lighting, etc., $6.74; a total of $13.17.

About one hundred and seventy-eight boys are employed to light and extinguish the lamps. These are paid $18.00 per month, and about 90 per cent of them are young men attending high schools or colleges. Many of them would not be able to go to school were it not for the money earned in this way.

The vapor lamps formerly cost the city $23.85. Under municipal control the cost has been reduced to $18.61 per lamp per year. The following table will show the total amount of money spent for street lighting and the cost per lamp per year, including the electric arc lights, which are still furnished under contract:

Year	Total Disbursements	Total Number of Lamps in Service	Average Cost per Lamp
1900	$238,617.85	8,425	$28.32
1901	259,227.90	9,163	28.29
1902	239,039.56	9,431	25.34
1903	271,648.35	9,631	28.20
1904	286,530.59	12,096	21.34
1905	266,208.10	12,830	18.39
1906	269,819.63	13,030	18.35

From the above it will be seen that there was a reduction of only 12 cents per lamp per year during the four years when the work was done under the contract plan, while there is a reduction of $7.50 between the years 1903 and 1906. In addition to this saving on each lamp for the last three years, the city has also accumulated property consisting of lamps, supplies, equipment—such as horses, wagons, ladders and tools of all kinds—amounting to $80,609.51, all of which was paid out of the disbursements above given, and by distributing this over the years 1904, '05 and '06 it would amount to a still further reduction of $2.35 per lamp. Thus municipal ownership has practically effected a saving of $9.85 on each lamp during the period referred to.

It will also be noted that the number of lamps in service has been increased from 8,425 in 1900 to 13,030 in 1906, this being an increase of 55 per cent. The population of Cleveland in 1900 was 381,000, and in 1906 estimated at 465,000, which would be an increase of but 22 per cent, thus showing that the service under municipal control has not been retarded. The cost of maintaining lamps during the same period has been reduced 40½ per cent. The figures above given, however, do not include interest on the investment. This would, of course, make some slight difference.

FOREIGN ITEMS

STANDARD SPECIFICATIONS FOR INCANDESCENT LAMPS

The Engineering Standards Committee has issued a standard specification for incandescent electric lamps. This specification is the work of the sub-committee on physical standards under the chairmanship of Dr. R. T. Glazebrook. The committee included Commander H. W. Richmond, R.N., and Mr. C. H. Wordingham, representing the Admiralty; Colonel H. C. L. Holden, R.A., Captain A. H. Dumaresq, R.E. (retired January 31, 1906), and Captain E. O. Henrici, R. E.. representing the War Office; Mr. Martin F. Roberts, representing the General Post Office; Mr. C. D. Taite and Mr. George Wilkinson, nominated by the Incorporated Municipal Electrical Association; Colonel R. E. B. Crompton, C.B., Captain H. R. Sankey, R.E. (retired) and Mr. A. F. Berry. Mr. Leslie S. Robertson, M.I.C.E., has acted as secretary, and Mr. C. Le Maistre, A.M.E.E., as electrical assistant secretary.

The question of standardizing carbon-filament glow lamps was referred to this sub-committee in June, 1905. The sub-committee have had the assistance of official representatives of the Incorporated Municipal Electrical Association, and also of some of the members of the sub-committee on generators, motors, and transformers. At the commencement of their labors the sub-committee through the courtesy of the manufacturers, obtained particulars as to the tests with which they were able to comply, and a conference was convened in November, 1905, upon the results of which a preliminary specification was drafted. A second conference was held in April, 1906, at which the draft specification was discussed. At this meeting the manufacturers desired considerable alterations in the specification, and a small sub-committee, consisting of Mr. I. W. Howell, Mr. E. A. Gimingham, and Mr. C. Wilson, was appointed by the conference of British glow lamp manufacturers (Mr. T. J. Grainger, chairman) to confer with the sub-committee, and the specification now issued is the result of this coöperation. At the request of the manufacturers, the sub-committee desire to suggest that this specification should not come into general use before July, 1907. The sub-committee express their appreciation of the valuable services rendered by the manufacturers' sub-committee.

The specification, which is the outcome of a great deal of work, contains technical provisions only such as can be well incorporated in a commercial contract. The standard of light adopted is the 10-candle-power Vernon Harcourt pentane lamp at the National Physical Laboratory. Secondary standards for the tests described will be suitable carbon-filament glow lamps certified to be in accordance with the standard. The gauges for determining the dimensions of the lamp cap are fully described in the specification, and standard gauges for this purpose are in the custody of the National Physical Laboratory. Limit gauges certified to be in accordance with these will be issued. In the specification, the useful life of a carbon-filament glow lamp is defined as the time taken for the mean horizontal candle-power of the lamp to drop twenty per cent from its standard value when run under standard conditions.

The efficiency of a lamp is defined as the number of watts the lamp dissipates per mean horizontal candle-power. Lamps of 8, 12, 16, 25, and 32 mean horizontal candle-power are standardized for the pressures of 110 and 220 volts. They are divided into two classes, having a useful life respectively of 400 and 800 hours. All lamps are to be marked with the standard mean horizontal candle-power, the voltage for which they are supplied, and a reference letter which denotes the efficiency of the lamp. Of course, the trade mark of the manufacturer will also appear. The specification then goes into the tests to which lamps shall be subjected. These are classified under seven different headings, as follows: (1) size, workmanship, and uniformity of shape (mechanical defects); (2) insulation; (3) vacuum; (4) initial candle-power; (5) watts per mean horizontal candle-power; (6) total watts; (7) life tests.

The tests will be taken on at least five per cent of the lamps in the consignment, and the failure of one-tenth of the lamps to pass under the first three headings will result in a further trial of five per cent from the consignment. If one-tenth of these fail to pass, the whole consignment will be liable for rejection.

The tests for mechanical defects are designed to reveal loose caps and other defects in capping or mounting, lack of continuity in circuit, discolored bulbs, and spotted filaments. For evenness of filament the lamps will be tested by being subjected to approximately forty per cent of their standard pressure, and viewed in this condition.

The general form and size of the cap will

be tested by limit gauges. The insulation resistance between cap and filament taken at the manufacturers' works must not be less than 1,000 megohms. The vacuum trials will be made at the manufacturers' works, and the details of this are not specified. The lamps which have passed the initial trials will be tested for their candle-power, efficiency, and total watts. If ninety per cent of the selected samples do not come within the individual limits in the annexed tables, and the average fall within the average limits, the whole batch will be liable to rejection. The following are approximately the limits allowed in the tables: mean horizontal candle-power—individual limits, twelve and one-half per cent; average limits, eight per cent; total watts—individual limits, eight per cent, average limits, five per cent; watts per mean horizontal candle-power limits, sixteen per cent.

The specified test for useful life provides that not less than five per cent (never less than five lamps) of those lamps tested shall be selected for testing for maintenance of candle-power, those lamps being chosen which most nearly approach the standard in the mean horizontal candle-power and total watts given in the annexed tables A, B, C, D, columns four and six. These lamps shall be run on a circuit in which the excess of pressure during the test does not exceed one-half per cent. The axis of the lamp during this test shall be inclined at an angle to the vertical not exceeding forty-five degrees. The pressure on each lamp shall be so adjusted that, at the commencement of the test, the lamp is burning at its standard efficiency. The test shall be at an end when the mean horizontal candle-power shall have dropped twenty per cent from its standard value.

Measurements of mean horizontal candle-power and current shall be taken at intervals of not more than 100 hours during useful life. The first measurement to be taken at the end of approximately fifty hours in order to determine the point of maximum candle-power. The result shall be plotted in such a manner that the average total candle-power hour area during useful life may be computed. This shall not include any area which is cut off by a line six and one-quarter per cent above the standard candle-power. The average total candle-power hours during useful life shall not be less than ninety per cent of the standard figures, otherwise the entire batch from which the lamps have been selected shall be liable to rejection. The ratio of mean spherical candle-power to mean horizontal candle-power shall not be less than 0.8, and in computing the mean spherical candle-power the light cut off by the cap shall not be included. Lamps burning at a higher efficiency than given in the annexed tables may be accepted as standard, but in this case the limits of variation in efficiency and total watts shall be the same percentage as those given above, and on life tests the lamps shall be run at their nominal rated efficiency.

In an appendix to the specification the following maximum dimensions are recom-

Standard Rating				Individual Limits		Average Limits		
M.H.C.P	Watts per M.H.C.P.	Total Watts	Candle Hrs Area at Standard Efficiency	Candle Power	Total Watts	Candle Power	Total Watts	Watts per M.H.C.P. Limits
			A. 110 VOLTS. 400 HOURS USEFUL LIFE.					
8	3.25	26.0	2900	7–9	23.4–28.6	7.4– 8.6	24.2–27.8	2.7–3.8
12	3.20	38.4	4350	10.5–13.5	34.6–42.2	11.0–13.0	35.7–41.1	2.6–3.8
16	3.10	49.6	5800	14 –18	45.6–53.7	14.7–17.3	47.1–52.1	2.6–3.6
25	3.15	78.75	9100	22 –28	72.4–85.0	23.0–27.0	74.8–82.8	2.6–3.
32	3.15	100.8	11600	28 –36	92.8–108.8	29.5–34.5	95.8–105.8	2.6–3.6
			B. 220 VOLTS. 400 HOURS USEFUL LIFE					
8	3.90	31.2	2900	7 – 9	28.1– 34.3	7.4– 8.6	29.1– 33.3	3.2–4.6
12	3.80	45.6	4350	10.5–13.5	41.1– 50.1	11.1–12.9	42.4– 48.8	3.1–4.5
16	3.70	59.2	5800	14 –18	54.5– 63.9	14.75–17.25	56.3– 62.1	3.1–4.3
25	3.80	95.0	9100	22 –28	87.4–102.6	23.3–26.8	90.3– 99.7	3.2–4.4
32	3.80	121.6	11600	28 –36	111.9–131.3	29.5–34.5	115.6–127.6	3.2–4.4
			C. 110 VOLTS. 800 HOURS USEFUL LIFE					
8	3.75	30.0	5800	7 – 9	27 – 33	7.4– 8.6	27.9– 32.1	3.1–4.4
12	3.60	43.2	8700	10.5–13.5	38.9– 47.5	11.1–12.9	40.2– 46.2	3.0–4.2
16	3.50	56.0	11600	14 –18	51.5– 60.5	14.75–17.25	53.2– 58.8	3.0–4.0
25	3.60	90.0	18200	22 –28	82.8–97.2	23.2–26.8	85.5– 94.5	3.1–4.1
32	3.60	115.2	23200	28 –36	106.0–124.4	29.5–34.5	109.5–120.9	3.1–4.1
			D. 220 VOLTS. 800 HOURS USEFUL LIFE					
8	4.50	36.0	5800	7 – 9	32.4– 39.6	7.4– 8.6	33.5– 38.5	3.7–5.3
12	4.20	50.4	8700	10.5–13.5	45.4– 55.4	11.1–12.9	46.9– 53.9	3.5–4.9
16	4.10	65.6	11600	14 –18	60.4– 70.8	14.75–17.25	62.4– 68.8	3.5–4.7
25	4.25	106.2	18200	22 –28	97.7–114.7	23.3–26.8	100.9–111.5	3.6–4.9
32	4.25	136.0	23200	28 –36	125.2–146.8	29.5–34.5	129.2–142.8	3.6–4.9

*A variation in these Standard Voltages of + 10 % is permitted, as stated in the Committee's Report No. 17, published in July, 1904.

mended: for lamps up to 16-candle-power —over-all length, 4⅜ in.; diameter, 2⅜ in.; for lamps of 25- and 32-candle-power —over-all length, 5 in.; diameter, 2⅝ in. The surfaces for contacts should not be less than 4.45 in. long or more than 0.20 in. wide.

Where lamps are tested for maintenance of mean horizontal candle-power at constant pressure instead of for standard efficiency, the standard to be adopted is seventy-five per cent of the average useful life and candle-power hours. Thus the standard useful life of lamps so tested will be 300 and 600 hours respectively for the two grades. The full specification can be purchased from the Engineering Standards Committee, the published price being 5*s*. .

THE ZIRCON-WOLFRAM METALLIC-FILAMENT LAMP

From *The Electrician* (London), Jan. 18, 1907.

Last week, after the reading of Mr. Swinburne's paper at the Institution of Electrical Engineers, much interest was taken in the exhibition of a metallic-filament lamp, known as the Zircon-Wolfram lamp, suitable for pressures of 200 to 220 volts, as hitherto it has been imposible to get a metallic-filament lamp suitable for high pressures.

It appears that this lamp in the invention of Dr. Zernig, of Berlin, who has been working at the subject for some years. The filament was originally made of zirconia mixed with carbon. This gave a high efficiency filament, but only suitable for low pressures. Subsequently tungsten was introduced. As to the exact process used, it is difficult to obtain any exact information, but it appears that it depends upon utilizing hydrogenous combinations of metals. Nitrogenous combinations have also been used, but they are less suitable as higher temperatures have to be used in the chemical operations. Hydrogenous combinations seem to have been first used by Winckler, but only to a slight extent. The material that is obtained is in such a form that the filaments can be made by a process of squirting, which, of course, is a very great advantage, as it is probably owing to this that low candle-power lamps can be made. Lamps are at present made for 16 candles on 100 volts, or 32 candles on 200 volts.

The introduction of tungsten into this particular lamp has enabled an extraordinary rapid advance to be made in the pressure at which it will run. Thus, although the pressure was only 37 volts rather more than a year ago, this pressure has now been raised to 220 volts. The advantage in being able to adhere to the simple squirting process is seen not only in low candle-power but also in the cost of manufacture. which is said not to exceed that of the manufacture of carbon-filament lamps by more than 1*d*. per lamp. This, of course, does not mean that these lamps will be put upon the market at practically the same price as the carbon lamp, but it is proposed to sell them at 2*s*. 6*d*. to 3*s*. each, which cannot be regarded as excessive for a high efficiency lamp.

As to the results obtained, the lamp has been found to run equally well on alternating as on direct current. It is not fragile, and the efficiency is about 1.2 watts per candle. Early tests on 37-volt lamps at the National Physical Laboratory gave excellent results. According to a test carried out by the Westminister Electrical Testing Laboratories in the spring of last year, the efficiency of a 115-volt 35-candle-power lamp varied from 1.75 at the start to 2.24 at the end of 1,000 hours; but the report of a later test, carried out on the Continent at the end of last year on some 200-volt 65-candle-power lamps, showed a considerable improvement on this, the efficiency being about 1.38 watts per candle at the start, and about 1.28 after 500 hours.

For the purpose of investigating the merits of this lamp the Zircon Syndicate (Ltd.) of 24 Budge Row, E.C., has been formed. We are indebted to Mr. H. J. Dowsing for the information here given.

THE CEROFIRM MANTLE

From the *Journal of Gas Lighting*. (Eng.) Jan. 22, 1907.

The Cerofirm gas mantle was yesterday introduced to a number of gentlemen in the city, at a little meeting specially arranged to demonstrate its merits. This is the mantle which formed the subject of a highly interesting article by Dr. C. R. Böhm in our columns on the 25th ult.; and those who saw the demonstrations with the mantle yesterday, and those who read this brief reference to what was seen, will desire to most carefully study that article for the purpose of ascertaining just wherein the mantle varies from the ordinary forms of manufacture. As was pointed out in the article, the base of the mantle is artificial silk, the fabric is impregnated in the ordinary manner, and then the thorium salts are heated with hydrogen peroxide; and, by this treatment, a thorium hydrate is obtained which does not expand but coheres. Now what is claimed is that the discovery of this particular treatment gives an exceptionally strong and flexible mantle and a mantle whose illuminating properties are well preserved. So far it was possible to do so in a short time (except, of course, with regard to the illuminating power),

Herr Bruno and his colleagues who are interested in the mantle demonstrated the veracity of their contentions. Several samples of the mantle were burned off in the presence of the visitors, then placed on a shock machine, and subjected to an arm-tiring number of violent vertical shocks—without damage. Mantles were twisted round the finger—without damage. Mantles were hooked on to the free end of a pliable wire held fixed at the other end, and the skirt of the mantle was pulled until the wire was bent—again without doing any damage to the mantle. There could be but one opinion that the mantle justified the claim to excellent merit in this regard; for practically all the violent treatment that a mantle could be subjected to without intentionally wishing to terminate its useful career, these mantles stood most boldly. The mantle, after being folded, too, revealed its fine elasticity by regaining its shape immediately on being replaced on a burner. Examples were also immersed in water to show that the value constituents of the mantle are insoluble in water, whereas it was possible by the same treatment to precipitate the salts of the ordinary mantle. The object of this test was only to demonstrate that the Cerofirm mantle was not in any way affected by moisture, nor by storage in damp places. With regard to the illuminating power of the mantles, there were no means of photometrically testing this; and as this is a mantle whose light, according to the inventor, is not at its best until, say, the lapse of several hours' use, it was not seen to the greatest advantage. But after a few minutes' burning, there was a distinct improvement to the eye in the illuminating power. Dr. Böhm, in his article, mentioned an average lighting power of 120 to 130 Hefner candles, with ordinary gas pressure and consumption; and certainly so far as yesterday's experience enabled judgment to be made, the mantle will give a good account of itself in this respect. But the striking feature was its structural tenacity, notwithstanding the beauty and fineness of its mesh. The mantle we learn has been largely adopted in Germany; and it is expected that it will not be long before we shall hear more about it in this country.

"PETROLIT" INVENTION

From *The Canadian Engineer*, Feb., 1907.

An invention made by the Swedish marine engineer, Mr. Hugo Medberg, and which, it is said, will be a hard competitor against kerosene oil for both lighting and power purposes, appears to be an assured success, according to the Swedish paper, *Dagens Nyheter*. The inventor himself has already disposed of the patent a couple of months ago at a comparatively insignificant price, while the present owners of the patent, who are Swedes, ask 30,000,000 francs for it, and they already have offers from many holds. Even Rockefeller is said to have entered into negotiations to acquire the novelty, which he fears will be a dangerous competitor.

The invention consists in the producing of a stuff which is given the name "Petrolit," and with quite remarkable properties. The light, which this new article gives, is said to be stronger and more pleasant than that of kerosene and the energy for power purposes greater than a corresponding quantity of kerosene. "Petrolit" is produced from common wood-tar, which under the influences of certain stuffs (this is the secret of the invention), is mixed with water. In countries with plenty of wood-tar, the new product will come very cheap, and it is figured that "Petrolit" may be sold for less than one and one-half cents per litre or about six cents per gallon.

If the invention holds what it promises, it will readily be seen of what enormous consequences it will be. Trials have proven that "Petrolit" is fully as well fit for automobiles as benzine. Another advantage over both kerosene and benzine is that "Petrolit" burns absolutely odorless.

THEATRE LIGHTING AND VENTILATING

From *Electricity and Electrical Engineering*, (London), Feb. 1, 1907.

The latest of London theatres, which was opened last Monday, January 28, is the Playhouse, erected for Mr. Cyril Maude on the site of the old Avenue, in a position which has been greatly improved by its having become the centre of the Embankment and Charing Cross stations of the various new electric tubes and their connections, by means of which it has become pleasantly accessible from all parts of London. The theatre, in the ornamentation of which good, *i. e.*, quiet and artistic, taste has replaced garishness, is remarkable for its simple and effective electric lighting, and for a thorough system of ventilation by means of electricity, and has thus become one of the most comfortable houses of the metropolis, from which the adoption of the plan of booking for gallery seats will by no means detract.

The supply of current is obtained at 200 volts from two separate supplies from the mains of the Charing Cross and Strand Electric Lighting Company. The cross-over switches are in a small intake room in the basement, which contains nothing beyond the Company's fuses. The total

supply will average about four hundred amperes; of this amount 300 amperes are required for the stage. The overhead lighting here consists of four battens, each with a three-color gamut composed of fifteen red, fifteen blue, and forty-four white 32-candle-power incandescent lamps. A line of seventy-seven similar lamps constitutes the foot-lights. The orchestra is below these, out of sight of the audience. No arcs are installed, and the ordinary lime light will be used for those effects. There are twelve stage dips. The stage switchboard, which is on the principle of that installed in the Coliseum (Mr. Wingfield Bowle's design) with an eight-wheeled regulating and dimming gear, also controls the centre lights in the auditorium. This forms not only the principal, but almost the sole source of light in that part of the house, and the reposeful effect is further enhanced by the fact that all the lamps in the auditorium are varnished over so as to prevent the uncomfortable glare emanating from clear bulbs. A very pretty glass chandelier carries forty-two 16-candle-power lamps. This hangs down in the centre of a wide ornamental ring on the ceiling which is composed of fifty similar lamps set almost flush with the ceiling. Upon the dress circle rail a pleasing innovation will be noticed, greatly brightening the effect of festive pomp and splendor, viz., four Venetian lanterns, rising fifteen feet, in couples, to the right and left of the stage boxes, rich in antique gold and blazing with three 16-candle-power lamps each. The artistic touch is also made manifest in ten fantastic bull heads of dull bronze, each carrying two lamps. These are placed around the stalls. Each stall is a comfortable and separately-placed armchair, with loose cushions, ornamented simply and effectively with its number within a laurel wreath, both embroidered in gold. There is no pit. The stalls fill the whole ground floor. The dress circle and gallery seats are of the most comfortable clap-up armchair pattern, and the whole is carried out in deep havannah and gold. Both upper tiers rest on girders, and are tilted in such a fashion as to allow an uninterrupted view of the stage from any part.

The principal lobby is lighted by a golden shell showing six incandescent lamps, and hiding six others which throw the light on the ceiling. A pretty 16-light Empire lantern hangs from the ceiling of the outer lobby, and 3-light Empire brackets are placed on the sides. All the staircases are lit by electric bulkheads placed almost flush with the ceiling.

A very pretty pattern of gilt lamps hanging on chains has been adopted for the dress circle and stall bars. The lighting of the front of the theatre has not yet been completed. There will be forty-two incandescent lamps on the shelter over the main entrance, and two arc lamps on top of that. It is further proposed to add—if permission can be obtained—a street sign, designed in the Old Empire style. This alone will use a 10-ampere circuit.

In all there are about three hundred and fifty lights, the electroliers all varying in design; for example, a simple 4-lamps crystal device having been chosen for the King's retiring room, which is reached by a separate staircase leading from the royal box. This room is heated by an electric radiator. The latter are also to be found in some of the dressing rooms, each of which has two or three lamps and three plugs for dressing-table purposes. These rooms are in the basement and are ventilated by two electric fans, one driving in cool air, while the other removes the vitiated atmosphere. Both fan motor-chambers are easily accessible. The auditorium is also ventilated by a larger one of these fans, consisting of a 4-horse-power exhaust fan placed on the top of the centre of the ceiling, and a 4-horse-power motor driving a sirocco-fan. This device is connected by wires with the safety curtain, so that when that curtain is lowered the motor is short-circuited, and the fan stops working, so that in case of fire the ascending smoke is not whirled about to the inconvenience and danger of the persons occupying the upper parts of the house. All the wiring is laid in solid screw steel tubes through the entire building. The master switches of the auditorium supply are under lock and key in a specially constructed cupboard.

The whole of the work has been carried out by Messrs. Maple & Co., and reflects the greatest credit upon all concerned in the same. Mr. Wingfield Bowles was the consulting engineer, Mr. T. C. Martin supervised the installation on behalf of Messrs. Maple, and Mr. H. Pemberton, late of the Coliseum, is the electrical engineer for Mr. Cyril Maude.

Commercial Engineering of Illumination

THE COOPERATIVE ELECTRICAL DEVELOPMENT ASSOCIATION

Abstract of Report of J. Robert Crouse, presented at the meeting held in New York, December, 1906.

Before describing briefly the active work which has been done during the past year, it will doubtless be well to briefly refresh your minds as to the objects of the Association as set forth in the constitution, which are: First, the promotion of the increased and more extended use of electrical service by the public for light, heat and power against all competitors for like service as an end in itself, and as a means to the increased demand for electrical apparatus and supplies, and the co-operative planning and execution of the various means and methods effective to this end.

Second, the establishment of co-operative relations, both moral and financial, among the different electrical interests, from the manufacturer to the consumer, to the end that each may contribute in some measure toward bringing about the above results desired in common by all.

The ground on which the contention is based that limited commercial co-operation is feasible, fair and profitable for the manufacturing, central station, and other electrical interests, is the almost absolute dependence of the manufacturer making generating and distributing apparatus and supplies for his market, upon the commercial activity of the manufacturer who produces the final utilities through which the market common to all—the public—is in the end electrically served, comparatively few in number, as will be observed; in the field of light, the incandescent, the glower, the mercury-vapor, the tube and the arc lamp; in the field of heat, miscellaneous appliances for domestic and industrial purposes, and in the field of power, the motor in endless and detailed application.

The money value of these devices is only a fraction of the total volume of the manufactured product, yet they create a demand for all generating and distributing apparatus and supplies, and constitute the edge of the commercial wedge through which is opened up the market for all such apparatus and supplies—sockets, porcelain, wire, conduits, switches, motors, transformers, dynamos, engines, boilers, etc.

Likewise, in turn, the dependence of the manufacturers, jobbers and contractors, in varying degrees, upon the commercial activity of the central station and others in exploiting electrical service to the public; and ultimately the dependence of us all in turn, like links in a chain, upon this great pre-occupied, incredulous and indifferent public, with a purchasing power of $18,-659,000,000 distributed among its 85,000,000 individual units.

The work which has been done by the Association during the past year may be briefly summarized as follows:

First: A large amount of literature has been issued by the Association in regard to itself, its objects and plans, which has made a strong appeal to the business sense and business imagination of the entire trade.

The Association offered a prize of $1,000 far papers on the "Organization and Conduct of a New Business Department for Central Stations," which brought out some of the best thought on the subject.

This, in turn, has been made widely effective through publication in all of the electrical trade papers, and through dissemination in pamphlet form.

Other commercial literature, such as a complete tabulation of applications of electricity, has been issued which it is not essential to review in detail at this time.

Second: Certain advertising agencies were interested in the work, for the purpose of affording to central stations and the distributing trade in general, the avenue through which could be secured, at reasonable rates, effective advertising and follow-up campaigns for local use.

The work of the advertising agencies, I believe, has been very effective, and large numbers of central stations, and some contractors and jobbers, have taken advantage of their service.

In addition, through the advertising agencies, there has been issued to central stations, manufacturers, contractors, jobbers, and their salesmen, and the trade in general, a campaign of commercial literature which aimed to emphasize the importance and opportunities for going after the public's business more aggressively.

All of this you are more or less familiar with, as it is arranged in logical order in your Exhibit Book No. 2,275, sent you some months since, and explained in some detail in Bulletin No. 2,275-A.

Third: The active co-operation of the electrical technical press was early secured and by the first of this current year all of the papers had opened up special departments devoted to the question of the ways and means of exploiting most effectively electrical service. Their work in this field has been covered in Bulletin No. 10,647, and may be summarized briefly in one paragraph as follows:

During 1905, 148 columns devoted to the general subject appeared in the technical press, while during this current year, 1906, 1,054 columns were devoted to the subject,

which, if capitalized at advertising rates, would amount to $15,700.

I understand that their decision to co-operate with this movement in the opening up of these departments, constitutes a departure in general technical press journalism, and must, therefore, indicate their interest in the entire campaign, as well as their disposition to contribute their full share in the work.

Fourth: A special effort has been made during the past year to interest the salesmen in the work of the Association.

The logical basis on which the salesmen's interest has been so far secured, and can be increasingly secured in the future, is well put in the following extract from a salesman's letter.

"Here's wishing the Co-operative Association continued success, as their success is my success."

The attempt has been made to familiarize salesmen with the plans of the Association, and in particular to secure their co-operation in presenting, by word of mouth, to the distributing trade the arguments and commercial data which were sent to them direct through the campaign of commercial literature, trade press, etc. There can be no question but what this has had a very marked stimulating effect in bringing about results.

Fifth; The particular point has been made to present the Association, its objects and plans, before electrical associations of various kinds. It was presented before the National Electric Light Association in June at Atlantic City; before the National Electrical Contractors in July; before the Electrical Jobbers at Niagara Falls in September; and before six State associations during the summer and fall. In each case it has had an attentive and respectful hearing, and the different associations have shown their interest by the appointment of committees which are to co-operate with the general Association. It has furnished in this manner an occasion for the discussion of the commercial phases of the business to a greater extent than, I believe, would have otherwise been the case.

Sixth: The possibilities of commercial publicity in the newspapers was tested out through the dissemination of an article entitled "The Electric Home," which was very widely used in Sunday editions, and the space devoted to it, capitalized at advertising rates, would have aggregated $10,000 and above.

Along the same lines, other electrical articles have been introduced into trade papers of allied industries, of which there are about a thousand, clearly demonstrating that the right kind of matter furnished to them will be freely used.

Broadly speaking, I believe that the general result which has been accomplished is the effective direction of the attention of the entire trade to the consideration of the possibilities of the commercial development of the business, particularly on the part of the distributing trade.

Admittedly, in the words of representative men in the distributing trade, the industry has been essentially technical, and attention has been very largely centered upon the engineering and operative phases of it.

The programs of the different state associations have been noticeable this year, for the notice taken and papers presented on the subject of "New Business Getting."

In addition, the technical press, both in its editorial comments and in its new business departments, reflects the vastly increasing attention being given to this subject.

During the past two months an effort has been made to get together the concrete results which appear to have followed this entire campaign.

These naturally pertain to the results in the central station field, inasmuch as well organized work has not been undertaken and has not been possible in the other fields, by reason of the insufficiency of funds as well as on account of the time necessary to prepare such campaigns.

I believe that while remarkably good results have been accomplished, yet they are to be qualified in terms of the general prosperity prevailing in all lines of business. Undoubtedly an unusual increase would have been enjoyed by the electrical business, regardless of the Association and its work. Individual judgment will vary on this, but the following figures will be found interesting and suggestive:

As an off-set against too great a discount of the result, the fact should be borne in mind that it has not been possible to secure complete returns on the results. The writer has personal knowledge of a number of such cases where the details are not available for use.

Most any way you analyze these results, I think you will be forced to the conclusion

	Business Resulting.	Evpense of Association.	Association' s Expenses Per Cent. of Business
Business resulting as figured	$20,000,000	$30.000	.0015
One-half business resulting as figured	10,000,000	30,000	.003
One-quarter business resulting as figured	5,000 000	30 000	.006
One-eighth business resulting as figured	2 500,000	30,000	.012

that this plan of co-operative commercialism—the massing of a small fraction of our combined selling forces on the public's business, opens up an avenue for increasing the sale of electric current, apparatus and supplies which is very highly efficient.

If you should credit the Association and those co-operating with it, with the fourth result above mentioned, it would more than have justified the original appropriation of $287,000 suggested in Denver in 1905, assuming a profit to the manufacturers of 15% on the increased business.

In conclusion, permit me to express my very great appreciation of the uniform courtesy, patience and co-operation which has been given to me in my personal relations with you all in the development of this work thus far. Whether or not it is written in the Book that our joint fortunes will lead us to the actual initiation of the Association, and the further prosecution of its work, we may all, I believe, feel some personal satisfaction in having made an honest and an earnest effort to evolve a commercial plan, which, while justifying itself in the cold dollar fashion of business, gave at the same time promise of improving both personal and trade relations in the future.

The incandescent lamp manufacturers are the generous fathers of this proposition, which Mr. Jackson at your last March meeting, was pleased to call my "baby." Carrying out the simile, I feel that it has now outgrown its swaddling clothes, has cut its eye teeth, finds a milk diet, in consequence, inadequate to its further development, has quite broken loose from its maternal apron strings, and appears before you as a very promising commercial youngster whose future growth and development must be entrusted to the larger interests and guidance of the whole electrical family.

A NEW HIGH EFFICIENCY INCANDESCENT LAMP PATENT

Under the title "Manufacture of Luminant for Electric Lamps" a patent was granted December 25 to Mr. John Allen Heany, of York, Pa., on an incandescent lamp filament consisting of a metallic alloy of tungsten and of titanium or similar metal. The original application, of which that of the present patent is a division, was filed December 29, 1904.

The specification states that the invention relates to the manufacture of luminants for electric lamps made of very pure refractory metals, such as tungsten, titanium, zirconium, etc., or alloys of two or more of such metals, or of pure chromium, molybdenum, thorium, manganese, or alloys of such metals. Such luminants have properties heretofore unattainable, such as being ductile and capable of standing a much higher temperature than any form of carbon or of the carbids of such metals and are more efficient than any hitherto known metallic filaments. They can withstand a much higher temperature and also convert the heat into light waves, and thereby have the properties of selective radiation. The above metals or osmium, cerium, niobium, tantalium and vanadium or boron and silicon are utilized either singly or mixed in a powdered form, as some of these powdered metals can be obtained by known processes more or less pure; or the pure oxides, hydrides, nitrides can be employed or metals in a very fine powder or in a colloidal state of the oxide or colloidal suspension of the pure metal and with the dry powder use a lubricant or binder, such as water or paraffin, to form or shape them. They are then baked in an oven to drive out the paraffin or water, and in case the oxide is used the filament is reduced metal. The preliminary baking does not oxidize the metal, but merely strengthens in a pure hydrogen by external heat to the it, and during this operation the binder is dissipated, leaving the filament formed of a refractory substance, strong, durable, and of good conductivity. The body is now heated by an electric current in a vacuum to drive out the hydrogen and to sinter or alloy the particles. If the filament is too large or rough, it may be rolled or drawn to the desired shape.

The present divided application is directed particularly to the production of an alloy of tungsten and titanium or an alloy of tungsten with some other metal.

It is well known in the art that when two metals in a finely divided condition are mixed with each other and heated under certain conditions they form alloys, and it is also believed by some that alloys generally melt at a lower temperature than either of the component metals; but the inventor states he has discovered that certain alloys of these above-mentioned metals in various proportions are very stable at high temperatures and appear to have the properties of selective radiation in a vacuum. The resistivity, flexibility, strength and shiny surface of these alloys can be regluated by the proportions of the constituents and by certain manipulation.

As an illustration of a suitable process, finely-powdered pure titanium nitride, which may be made by passing pure ammonia gas over heated pure titanium dioxide, is mixed with an equal volume of pure tungsten trioxide, which is also finely powdered and squirted through a suitable die, there being added a small amount of paraffin or water to act as a lubricant, and the filament is then baked to drive out the lubricant. The filament is now heated by

external heat, such as a gas flame, in a porcelain tube, through which an abundant supply of pure hydrogen is flowing for several hours, and the tungsten trioxide is by this treatment reduced to the metal, which remains mixed with the titanium nitride. The filament, after cooling, is removed from the tube through which the hydrogen is passing and mounted on the stem of the lamp. The bulb of the lamp is now exhausted and the filament is glowed at a bright temperature, care being taken that no vaporized oil arises from the pump into the bulb in order to prevent the formation of a carbide. By the action of the electrical current, which produces a very high temperature, the titanium nitride is dissociated and the nitrogen is pumped off while the titanium alloys with the tungsten. The filament shrinks both in cross-section and in length, and there results a dense shiny durable alloy filament of pure titanium and tungsten.

Another method consists in mixing titanium dioxide with tungsten trioxide and forming the mass into filaments by squirting through a die, there being added a small amount of water or paraffin; then driving out the water and paraffin by gently heating, and then reducing the filament, which is now composed exclusively of the two oxides mentioned, in the tube by hydrogen, whereby the tungsten trioxide is reduced to metal and the titanium is either converted into the metal or the suboxide, or a mixture of the two; the filament is then treated in a vacuum by an electric current, as above specified for the nitride and metal filament.

Various other proportions of the ingredients may be employed and excellent results may be obtained by using in place of the tungsten trioxide pure finely-divided tungsten up to as high as 95 per cent. mixed with 5 per cent. of titanium powder or powdered titanium nitride, or mixed with other refractory metal or metallic substance. The conductivity, strength and efficiency vary with the alloys of different metals, and good results may be obtained with a comparatively large percentage of tungsten alloyed with any of the above-named metals.

Following are the three claims of the patent:

A filament for incandescent lamps consisting exclusively of a metallic alloy of tungsten and titanium in a dense shiny coherent state and homogeneous throughout.

A filament for electric incandescent lamps comprising an alloy of tungsten and a metal which is stable and capable of being incandescent at a temperature at which platinum volatilizes, said filament having a high point of fusion and being electrically conductive, and being stable at an efficiency at which a carbon filament, or a filament containing metallic oxide will rapidly disintegrate, and being dense and homogeneous and having a shiny metallic surface.

The process which consists of forming a filament composed exclusively of a compound of tungsten and a compound of titanium and reducing both compounds to their respective pure metals, removing the non-metallic component elements and alloying said pure metals, and shrinking said filament into a dense homogeneous shiny metallic alloy filament.

DARKNESS AND DIVIDENDS

There is a scriptural passage to the effect that "some men prefer darkness rather than light because their deeds are evil." If by "darkness" is meant absence of sunshine, then the central station manager's deeds must be evil indeed; for the less sunshine the more dividends; and the "melancholy days" of the poet are the joyful days of the stockholder. Commenting on the fact that December and January were darker than for years past, the New York *Evening Post* says:

"It has been a hard fight to keep the whining dynamo and sagging tank ahead of the imperative calls of button and jet; but in almost every instance the emergency has been tided over. The winter of 1906-7 will always be remembered as a campaign, however, by the men whose business it is to understudy the sun.

"A scientific and exhaustive study of the caprices of the great lightmaker is to be made by the lesser ones, as a result of the extraordinary conditions which have obtained thus far this winter. The matter has been called to the attention of the Empire State Gas and Electric Association, an association of lighting men of the up-State territory, and plans have been proposed for obtaining exact records of the variations of sunlight during every hour of this record period of darkness. The coöperation of scientists and Government experts will be invited and a determined effort made to obtain some definite insight into the causes and probabilities of sudden, untimely and extended obscurity in the sun's rays.

"Philip T. Glidden, of Binghamton, has already begun, in the interests of the Association, an investigation of the instruments and methods employed in the Government service for observing and recording the variations in the sun's illuminating power. He is working out an instrument which, when perfected, is designed to record not only the periods of sunlight and unobscurity, but the most minute gradations and variations between them at every minute during an overcast day.

Miscellaneous News

Alameda, Cal.—At the meeting of the trustees last night the rates of the Municipal Light Plant were reduced 30 per cent. The rate heretofore has been 10 cents a thousand watts. The price is now 7 cents. The city lighting was reduced from 6 1-4 to 4 1-2 cents.

Albany, N. Y.—The second annual report of the Commission of Gas and Electricity, sent to the Legislature yesterday, shows that there is a total of 426 corporations, municipalities and individuals furnishing gas or electricity for light, heat or power in the state coming under the supervision of the commission.

The capitalization of these companies aggregates the sum of $546,000,000, and the gross income from operation approximates $75,000,000 per annum. Of this number, 51 plants furnish coal, water, or mixed coal and water gas, 162 electricity, 51 both gas and electricity, 12 acetylene gas, 13 gasoline gas and 41 natural gas. Of the municipalities engaged in furnishing light, 3 furnish gas and 35 electricity.

The commission makes several important recommendations to the Legislature as to legislation. The most important of these recommendations has to do with the question of complaints as to price, purity and quality of gas or electricity. As the law now stands, complaints can be made to the commission by the proper municipal authorities or by one hundred or more consumers of gas or electricity in the territory of the company complained of. The commission recommends that the law be amended so that complaint may be made by 25 customers in the territory served where it contains less than 1,000 population, by 50 customers where the population is between 1,000 and 5,000, by 75 customers where the population is between 5,000 and 10,000 and 100 in all other places. This amendment would make it possible for the consumers in any community in the state who consider themselves aggrieved to have an investigation, and the price regulated.

Albany, N. Y.—The commission of gas and electricity has taken action looking to fixing a standard of illuminating power and purity of gas for lighting purposes throughout the entire state outside of New York city, which has statutory provisions applicable to that city only.

The act creating the commission gives it authority to prescribe the minimum illuminating power and the composition, so far as impurities are concerned, which cannot be exceeded by any gas company in the state. These impurities recognized by the New York city law are ammonia, sulphur and sulphuretted hydrogen, the presence of which is detected by chemical tests. The illuminating power is detected by the photometer.

A notice has been served on all the companies outside of New York city supplying either coal gas, water gas, or mixed coal and water gas, that the commission is about to fix and establish such a standard, and that a hearing upon the proposed order will be held at the Capitol, February 21, at 10 o'clock, each company having an opportunity to be heard at that time. This affects some eighty-five companies, and all users of coal or water gas, outside of New York city.

Brownwood, Texas.—On account of the failure to make a satisfactory contract with the light plant for street lights there is strong talk of the city installing a light plant for street lighting purposes. The light situation is the talk of the city. The trouble between the light plant and the council is that the plant will not agree to give a certain voltage which the city believes it would be entitled to under the contract.

Herington, Kan.—Final arrangements have been made by the city council of Herington for the transfer of the electric light as well as the water plant from private corporations to the municipality.

Joplin, Mo.—At a meeting of the board of public works of the city of Joplin, held Friday, plans were outlined for a campaign for commercial lighting for the year 1907, during which time it is proposed to double the present amount of city lighting business and place a solicitor in the field.

Los Angeles, Cal.—Application was received from the Pacific Light and Power Company for a franchise to operate a system of poles and wires over the streets and highways of the county for the transmission of electric light and power. The franchise is to be in effect for fifty years, and after July 15, 1912, the county is to receive 2 per cent. of the gross receipts for power and light furnished outside of incorporated municipalities.

The board will advertise the franchise for sale.

Nashville, Ark.—The Nashville municipal light plant has become a burden to the city, and the council is now considering the ad-

visability of selling it. The company from which the plant was purchased is demanding the remainder of the purchase money, and threatens to sell the property unless the payment is met. There is no money with which to meet this payment, as all the revenues of the city have been swallowed up in the attempt to operate and pay for the plant, and the only thing remaining to be done is to either allow the company from which the plant was purchased to foreclose its lien or accept an offer made by a citizen of the town for the plant. At a meeting of the council Monday night a committee was appointed to confer with the man making the offer for the plant.

New York City.—By a decision of the Appellate Division of the Supreme Court, the Long Acre Electric Light and Power Company, recently acquired by the Manhattan Transit Company, gets the right to enter the city's electrical subway system.

It was announced at the time Justice Dowling issued his decision that the Long Acre company would go into the business of electric lighting on a large scale and would cut down existing electric light charges about one-half, with a profit to the company. Mr. Sheehan has asserted that the Manhattan Transit Company will support the Long Acre in its plans for developing a large business.

Niagara Falls, N. Y.—The illumination committee of the Board of Trade has taken another step in connection with the plan to illuminate the Falls which has been on tap for so many years. A committee was appointed to learn the attitude of the park commissioners on the matter and an effort will be made to have a joint conference between the officials of the two sister cities for a discussion of the proposition to have a joint illumination of the cataract. The joint illumination idea is a good one and with the coöperation of the Canadian officials and business men something out of the ordinary in the way of illumination should result.

Pasadena, Cal.—By an act of the council at today's session directing the clerk to advertise for bids for machinery and supplies to increase the capacity of the proposed municipal lighting plant to a unit to equal 1,000 kilowatts, the city of Pasadena proposes to thrown down the gauntlet to the Edison Company in the competitive field of commercial lighting.

Said City Attorney J. Perry Wood today: "We have practically decided to cut the present rates half in two. With the enlarged capacity of our plant we will be able to take care of all the business that will naturally come to us by reason of the cut in rates. Of course the city does not expect to capture the entire business of the community, as it is to be expected the Edison Company will meet our cut and of course that company will retain many of its patrons under any condition."

Philadelphia, Pa.—Indignant over the insinuations of certain men who have said that the contract with the Keystone Contracting Company for the lighting of the gasoline lamps of the city would never be signed, Mayor Weaver yesterday affixed his signature to the contract and personally took the document to the City Controller to be countersigned. The price named in the contract for lighting the 14,000 lamps during the year is $387,193.30, which is $30,000 less than the bid of the Globe Gas Light Company, that formerly did the work.

Sacramento Cal.—A committee of the Board of City Trustees is now engaged in an inquiry as to the cost and feasibility of installing a municipal lighting plant for Sacramento, and while it has not as yet ascertained the total cost of installing such a plant, nor the cost of operating, it is more than probable that it will report back favorably to the proposed scheme.

Salem, Ore.—Blazing all night long, the electric lights of the Capitol suggest an extravagance that not one taxpayer in 10,000 in Oregon can afford for himself. But as good fortune has it, the lights are not on meter and the taxpayers pay the same money whether they burn or not. The contracts for the electricity will expire March 3, 1908, however, and it is up to this Legislature to provide a new source of light, either by building a lighting plant for the state or by entering into a new contract with the electric company of this city. The present contract requires the state to pay a flat rate of 30 cents per light per month for each 16-candle-power light burned in the Capitol. That a flat rate contract encourages waste is very apparent to one who has been around the Capitol during the Legislative Assembly As the cost to the state is the same whether the lights are burned or not, the current it left turned on in many places where it would be turned off if the state were paying upon a meter basis. The same is probably true at the several institutions.

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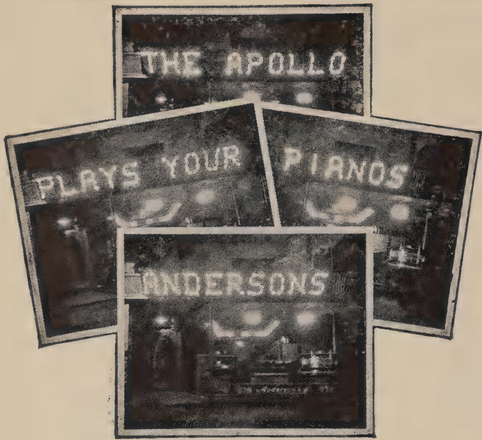

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AUTHORS

SUBJECTS

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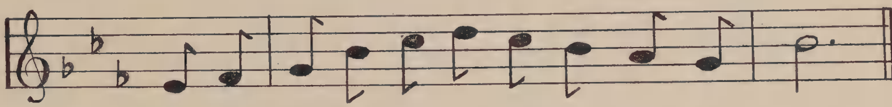
"HAVE YOU EVER HEARD IT TOLD THAT WAY BEFORE?"



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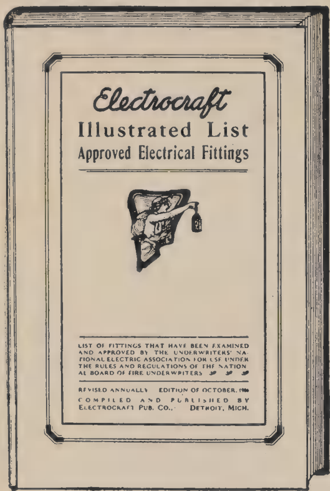

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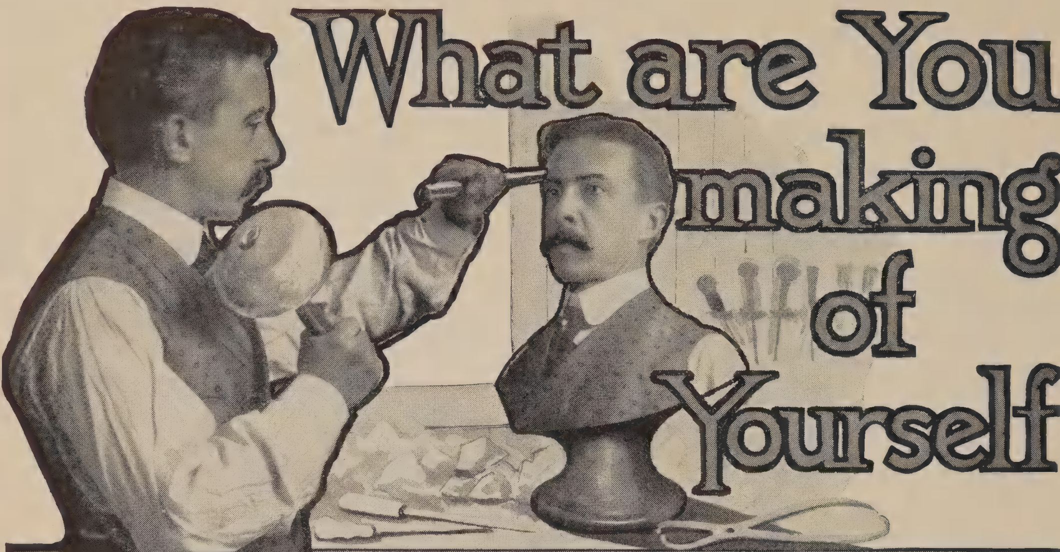

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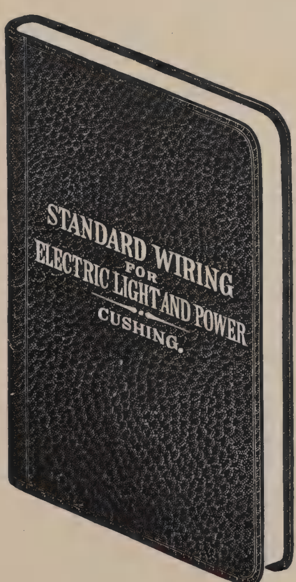

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